Instruments

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Vol. 21 AUGUST 1948 No. 8

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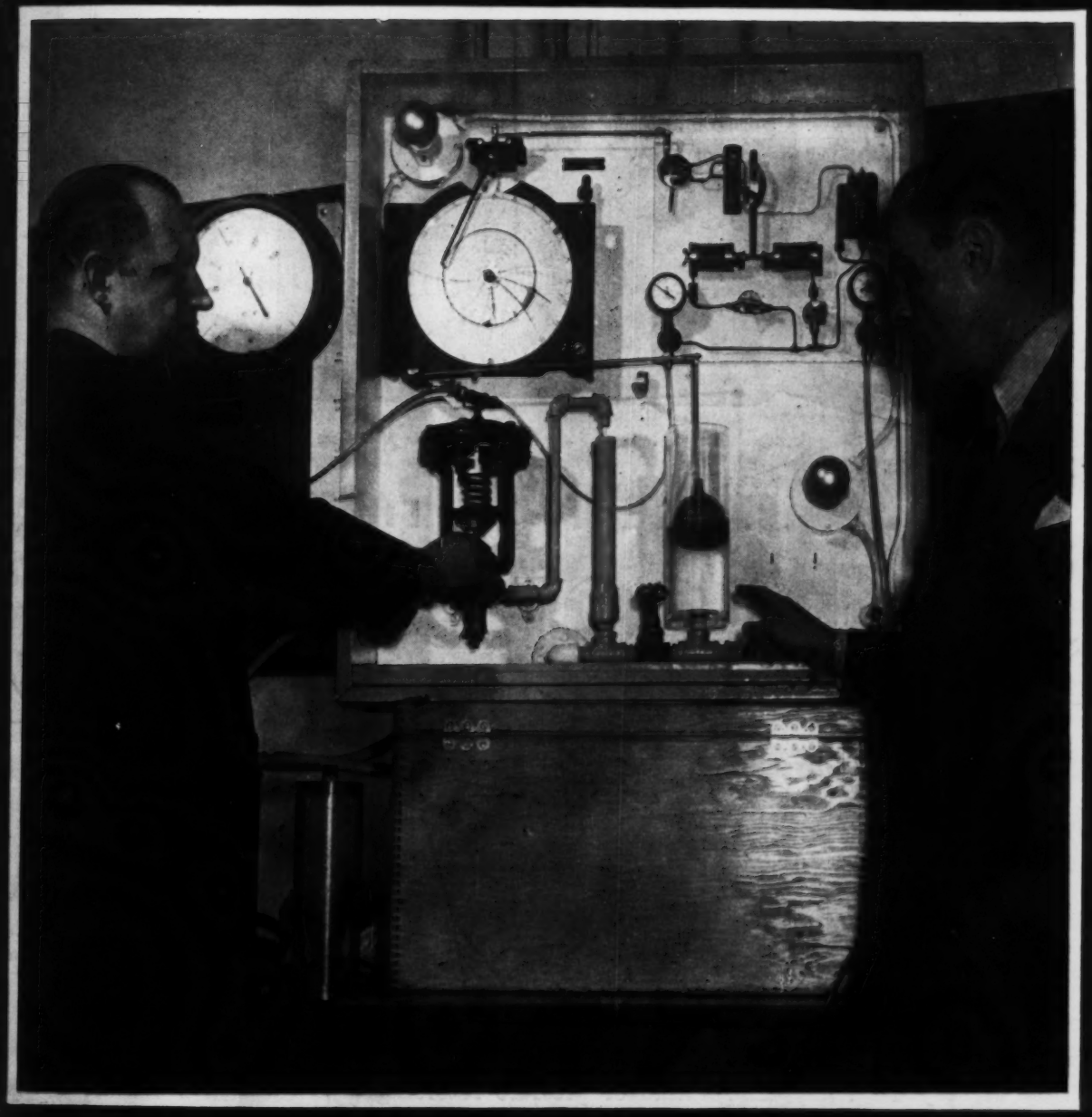

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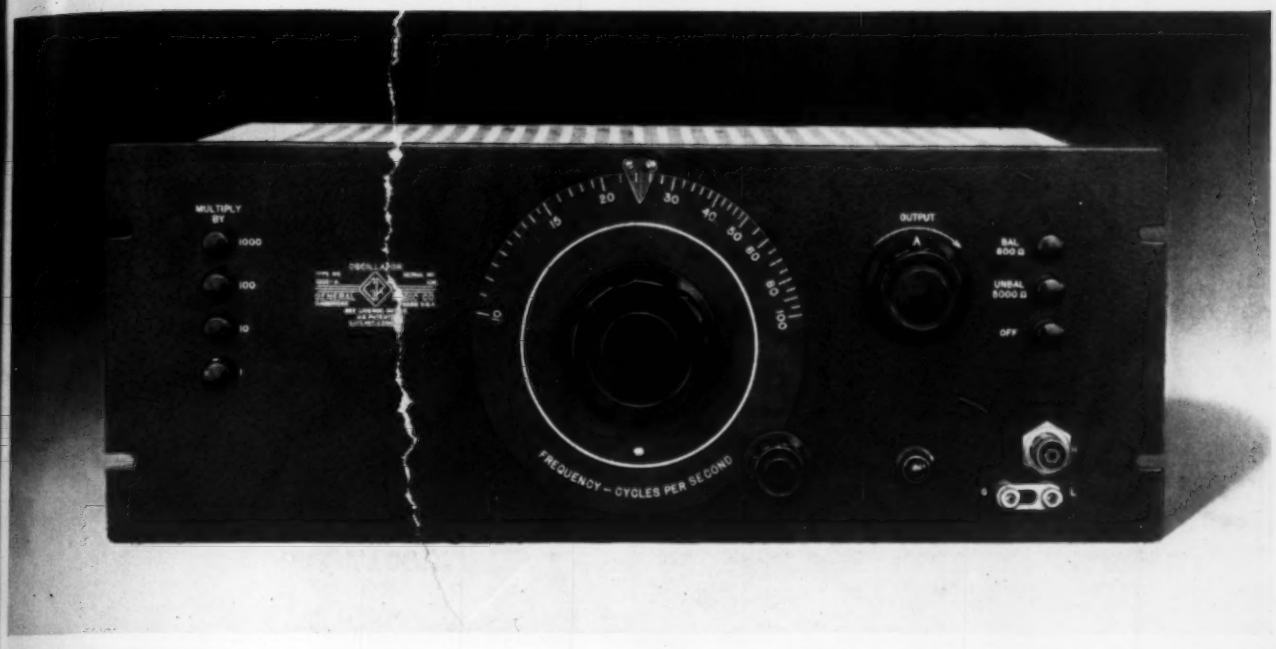

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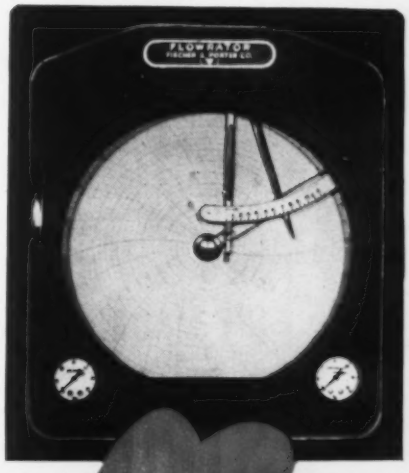

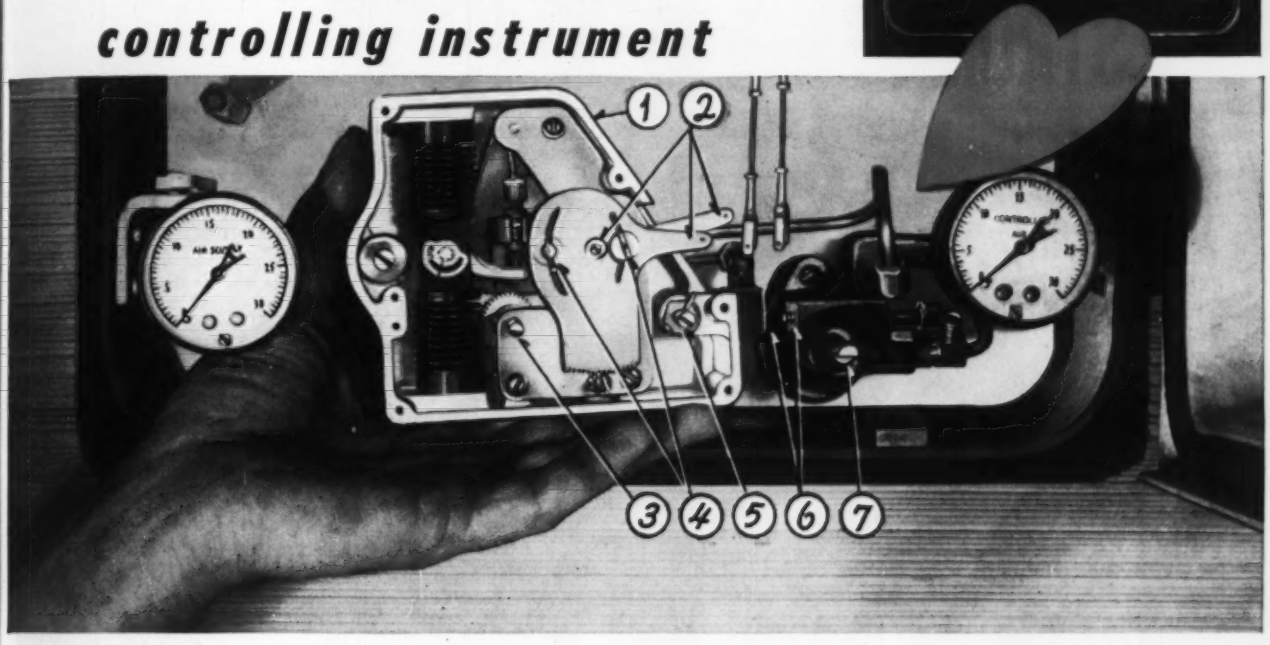

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3. 0 to 200% throttling range adjustment.
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Reset is calibrated accurately from 0.2 to 50 minutes guaranteeing "on the beam" results the moment the controller goes on stream.

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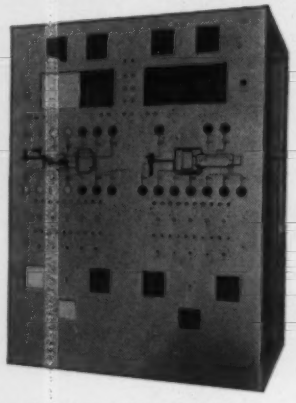


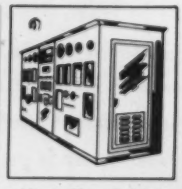
Falstrom refinery cubicle with mimic flow diagram in five colors.

TO the casual observer, this panel would merely be an example of particularly good metal workmanship. The engineer or technician, however, would see an additional asset. He would see at a glance that this cubicle had been properly designed, constructed and finished for high grade refinery service where nothing but the finest in materials or workmanship was tolerated. He would know this by the smooth cutout edges, non-glare surface coating, careful, professional multi-color diagramming and general overall top notch construction. Falstrom wants to build cubicles of this type for you; may we quote on your requirements. Write for Bulletin 119S.

STRUCTURES FOR EVERY CONTROL REQUIREMENT

New Knocked-Down Cubicles

Control Panel with Monitor's Desk



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Instruments

Vol. 21 AUGUST 1948 No. 8

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By M. F. Behar

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THE PRIMARY-ELEMENT RESPONSE

For Hairline Control "OFF TO A GOOD START" *Is Chief Requirement*

By M. F. BEHAR

YOU can't control what a variable condition was yesterday or what it was a second ago. You can only control what it will be—and then only if you observe the "Four Requirements":

"(1) The condition to be controlled, or its variation, must be measurable; (2) The primary element of the automatic controller must be suitable for the measurement involved and must be properly installed; (3) The power device commanded by the control instrument must adequately control an adequate source of energy or material; (4) The measuring means must command the corrective means effortlessly; i. e., without having its own measuring properties impaired."

Furthermore,

"The causes of unsatisfactory control always involve time element—lags, periods and delays. There never is any exception. . . . Dead zones mean dead times. . . . Dead times mean dead zones. . . . No controller can be better than its primary element. . . . It is possible to build a control mechanism without a dead zone but this is not true of any controller as a whole because a controller consists not only of an instrument but of everything from the primary element (including its bulb socket or thermocouple tube) to the final element (including its power unit). . . . Primary-element lag makes close control impossible . . . the controller is always too late with too little corrective action followed by too much corrective action."

In most processes, an ideal recorder would show that the controlled temperature fluctuates much more widely than is suspected by the human operator—or by the automatic controller. In Fig. 1 the solid line is an ideal record of the controlled temperature (supposed to be held at 580° ± 1°) and the dotted line is the record of an extremely slow primary-element response. At 1:05 o'clock a serious process disturbance made the controlled temperature drop rapidly but the controller could not initiate corrective action until ten minutes later, when its primary element's indication crossed the lower limit of the 2° differential.

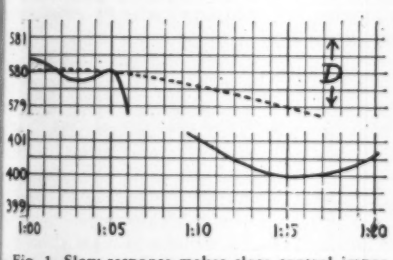


Fig. 1. Slow response makes close control impossible. This single sketch combines several in the disclosure on pages 57-62 of "Fundamentals of Instrumentation" (1932) to which the reader is referred for families of curves of dead-time dead-zone relations based on elements with exponential responses.

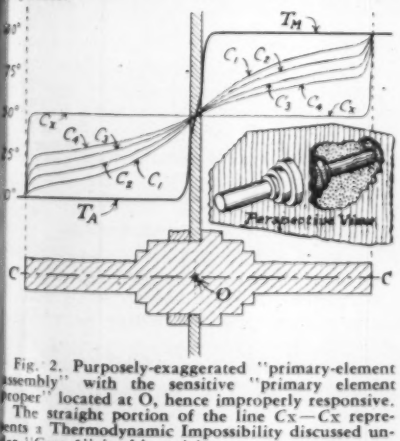
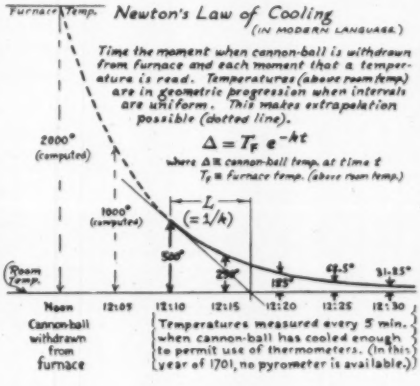


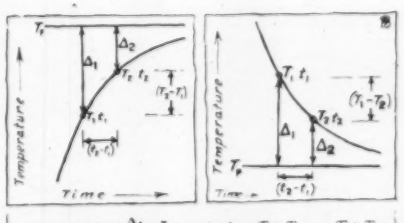
Fig. 2. Purposely-exaggerated "primary-element assembly" with the sensitive "primary element proper" located at O, hence improperly responsive. The straight portion of the line Cx—Cx represents a Thermodynamic Impossibility discussed under "Case 1" in this article.

A fine-wire resistance element, or a thermocouple junction hammered or rolled tissue-paper-thin, responds so quickly to temperature fluctuations, even in air, that it can be used as a speech pick-up. We can't use such a primary element bare in a control system. We must protect it and support it in a relatively enormous assembly whose characteristic time is a hundred times or ten thousand times longer than that of the bare primary element. When we neglect longitudinal conductance, the element is affected by wall temperature. The *reductio ad absurdum*, Fig. 2, shown as a lantern slide these last ten years, has made lecture audiences laugh, then think, then discuss, then think some more and resolve to act.

In the upper part of Fig. 2 there is used a "hybrid" method of graphic presentation found in text-books on heat transfer. Readers who have not studied such books are asked to study Fig. 2 for a minute, to become familiar with this graphic method and thereby be able to use the data presented in Figs. 5 to 15.


Furnace Temp.
Newton's Law of Cooling
(IN MODERN LANGUAGE)
Time the moment when cannon-ball is withdrawn from furnace and each moment that a temperature is read. Temperatures (above room temp.) are in geometric progression when intervals are uniform. This makes extrapolation possible (dotted line).
$\Delta = T_F\, e^{-kt}$
where Δ ≡ cannon-ball temp. at time t
T_F ≡ Furnace temp. (above room temp.)
2000° (computed)
1000° (computed)
L (= 1/k)
Room Temp.
Noon
12:05
12:10
12:15
12:20
12:25
12:30
Cannon-ball withdrawn from furnace
Temperatures measured every 5 min. when cannon-ball has cooled enough to permit use of thermometers. (In this year of 1701, no pyrometer is available.)

General Equation for Determining Time Interval between $I = T_1$ and $I = T_2$ when L is Known



$$t_2 - t_1 = \log_e \frac{\Delta_1}{\Delta_2} \times L \text{;} \quad \text{whether } T_1 > T_2 \text{ or } T_2 > T_1$$

Fig. 3. Above, an elementary explanation of the Newton-Harper Law; below, a convenient expression thereof.

The normal response curve, Fig. 3, was first described in 1701 by Newton when he proposed to measure furnace temperatures by taking "a pretty thick piece of iron red-hot" from the furnace, noting the time, waiting until it cooled enough to use thermometers [actually thermoscopes: "particles of several metals, and other fusible bodies"]; then "the time of its cooling was marked till all the particles were hardened": "the excess of the degrees of heat of the iron . . . above the heat of the atmosphere . . . were in geometrical progression when the times are in arithmetical progression." Later writers re-worded Newton's Law of Cooling by stating that, at any instant, the RATE at which Newton's cannon-ball cooled was proportional to the difference between its temperature and the air temperature. In 1912 B. D. Harper wrote a 56-page paper in the *Bulletin of the Bureau of Standards* discussing "Thermometric Lag" in such mathematical detail that his name should be used with Newton's by calling the perfect exponential response the Newton-Harper Law.

Harper's masterly dissertation made thermometer users, as well as makers, think in terms of the lag coefficient or "time-constant" (CHARACTERISTIC TIME is a better term), which is the time by which the reading of a thermometer exposed to a uniformly-changing temperature lags behind the true temperature; or the time for a thermometer to indicate 63% of a sudden change.

According to the Newton-Harper law, the thermometer's "temperature" at any instant is uniform throughout the mercury in the bulb. Harper did not question this assumption. Neither did instrument men question it until a few years ago. It was assumed that, during any transient, the instantaneous temperature of the mercury at the bulb axis was the same as the temperature of the mercury in contact with the bulb wall—or so nearly equal that the instantane-

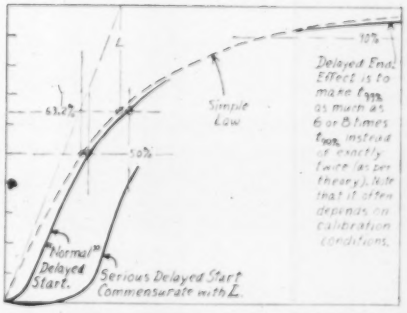

L
63.2%
50%
10%
Simple Law
Delayed End Effect is to make $t_{99\%}$ as much as 6 or 8 times $t_{63\%}$ instead of exactly twice (as per theory). Note that it often depends on calibration conditions.
"Normal" Delayed Start.
Serious Delayed Start Commensurate with L.

Fig. 4. This drawing (in larger size) illustrated the first published statement that no man-made thermometer obeys the Newton-Harper law and that ALL primary element assemblies have response curves with delayed starts or delayed ends or both.

ous gradients could all be drawn as straight lines. Respect for Newton and for the Bureau of Standards upheld this assumption and extended it to the responses of industrial thermometers and primary-element assemblies.

This assumption is false because heat does not travel at infinite velocity through mercury or through solids. Neither the inside NOR EVEN THE SURFACE of Newton's cannon-ball cooled as he announced that it did. For more than a century, scientists have discussed the Problem of the Cooling Sphere. The mathematical difficulties are formidable even for the simplest body, the sphere, and for complex industrial structures they are almost insurmountable. One of many reasons: properties and coefficients vary with temperature. Simplifying assumptions must be made.

About thirty years ago, the teaching of a-c. network and electronic equations began to spread throughout all engineering schools. About twenty years ago these equations began to be applied to heat-transfer problems. Results showed good agreement with predictions made by means of analogies with electric-circuit components. The idea occurred (no doubt to many persons independently) that even the simplest mercury-in-glass thermometer had three *RC* components and that the response of its column-top could not possibly be a simple exponential but had to resemble an S-curve to an extent depending, by electric-circuit theory, on the capacitance ratios: an imperceptible extent with a thin bulb, a noticeable extent with a thick bulb. The name "delayed start" suggested itself.

As with axial effects, so with longitudinal: the different well-known stem corrections for steady-state or equilibrium, when viewed in non-Newton-Harper light, became a modification of the last portion of the response curve. The name "delayed end" suggested itself (as applying to this departure from the exponential response but not to the wall error which is an eternally-delayed end: a permanent wrong reading).

So a crusade was conducted—a shameless, revolutionary effort to undermine respect for the Newton-Harper law among research men in several large instrument companies and large institutions. At first it was done privately. In May 1941 a public disclosure was made including a drawing reproduced here as Fig. 4. Later, a disclosure on slow response was made before a scientific body but not published. Part of this latter disclosure (a section entitled "The Three Cases") is now published for the first time—in highly-abridged form and "without math," but with some of the families of curves illustrating the three ways in which a simple body cools (or heats) when, after being in complete temperature equilibrium with its surroundings, it is subjected to one sudden change of ambient temperature.

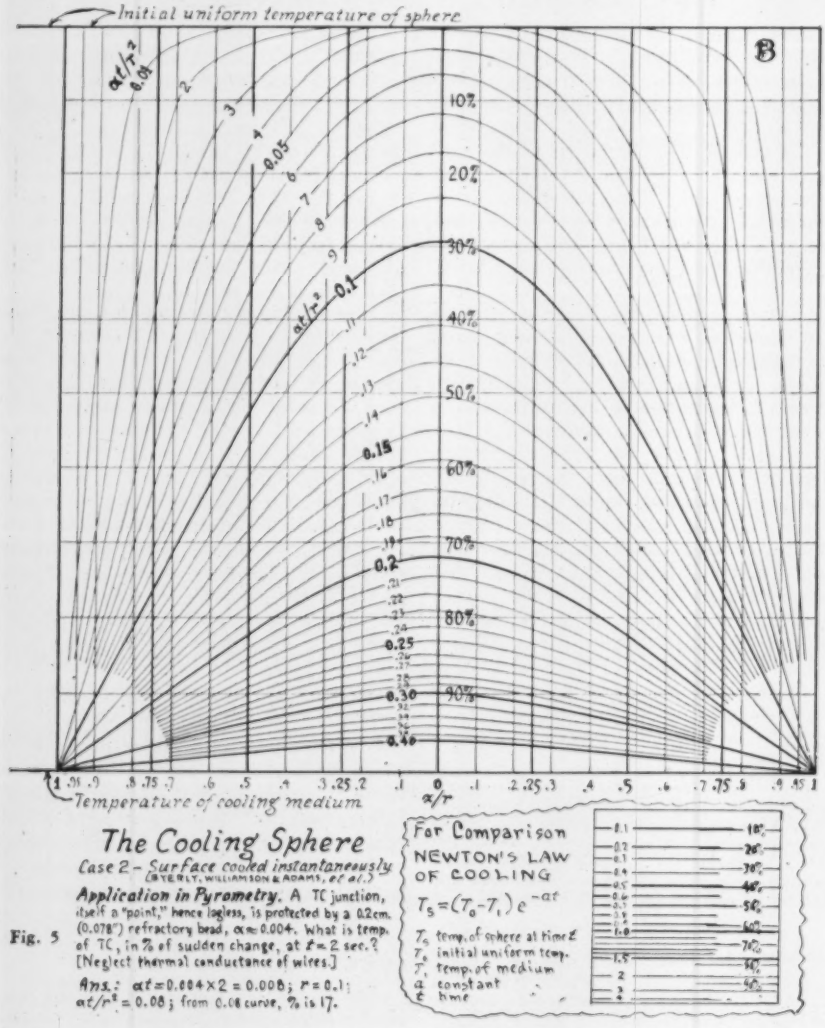

Initial uniform temperature of sphere
Temperature of cooling medium
α/r
B
The Cooling Sphere
Case 2 - Surface cooled instantaneously
(BYERLY, WILLIAMSON & ADAMS, et al.)
Application in Pyrometry. A TC junction, itself a "point," hence lagless, is protected by a 0.2cm. (0.078") refractory bead, α = 0.004. What is temp. of TC, in % of sudden change, at t = 2 sec.? [Neglect thermal conductance of wires.]
Ans.: αt = 0.004 × 2 = 0.008; r = 0.1; αt/r² = 0.08; from 0.08 curve, % is 17.
For Comparison
NEWTON'S LAW OF COOLING
$T_s = (T_0 - T_1)\, e^{-\alpha t}$
T_s temp. of sphere at time t
T_0 initial uniform temp.
T_1 temp. of medium
α constant
t time

Fig. 5

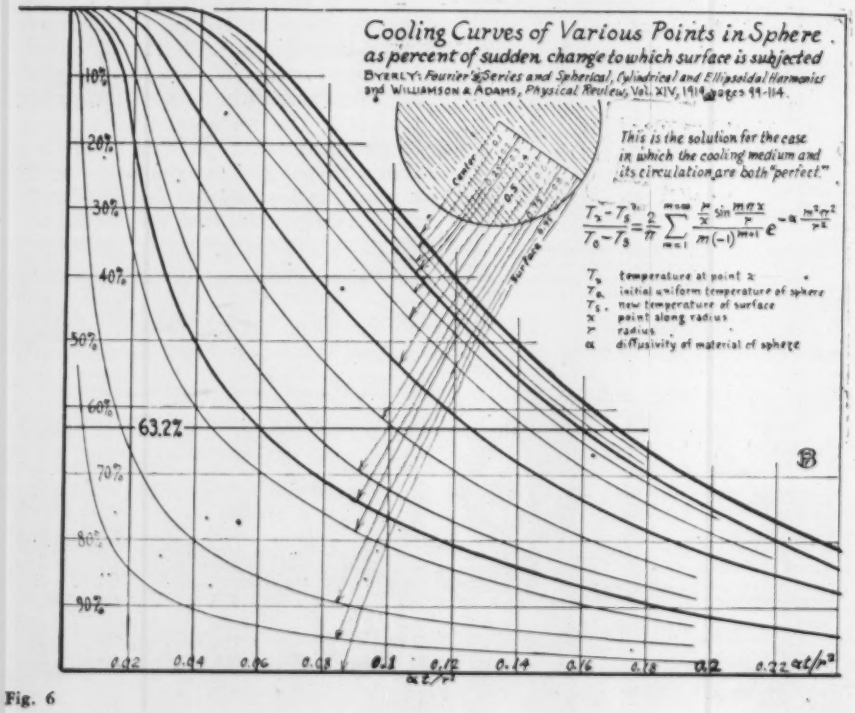

Cooling Curves of Various Points in Sphere
as percent of sudden change to which surface is subjected
BYERLY: Fourier's Series and Spherical, Cylindrical and Ellipsoidal Harmonics
and WILLIAMSON & ADAMS, Physical Reviews, Vol. XIV, 1919, pages 99-114.
This is the solution for the case in which the cooling medium and its circulation are both "perfect."
$\frac{T_x - T_s}{T_0 - T_s} = \frac{2}{\pi} \sum_{m=1}^{m=\infty} \frac{r}{x} \sin\frac{m\pi x}{r} \frac{(-1)^{m+1}}{m} e^{-\alpha \frac{m^2\pi^2}{r^2} t}$
T_x temperature at point x
T_0 initial uniform temperature of sphere
T_s new temperature of surface
x point along radius
r radius
α diffusivity of material of sphere
Center
Surface
63.2%
B
αt/r²

Fig. 6

"The Three Cases"

Chief causes of slow response are (1) poor heat transfer TO the primary-element assembly and (2) primary-element assemblies that are heavy, structurally complex, and geometrically poor: low surface/volume ratio.

The problem of poor heat transfer—in itself—will never be fully solved for all applications. Heat flows from a fluid to a solid (or vice versa) by reason of

a difference of temperature. The smaller the difference, the smaller the flow. The flow depends also on the resistances which impede it—exactly as does an electric current. These resistances exist at every surface. They are least when the fluid moves rapidly past the primary element assembly; they are high when circulation is zero. In other words, at zero circulation the CONDUCTANCE of heat has its lowest value—as if a high-resistance FILM surrounded the bulb or couple-protecting tube. Hence the expressions "film conductance" or "film coefficient" (in addition to "surface coefficient" which is a general term including radiation). The film coefficients for gases are, of course, much lower than those for liquids, but different liquids have enormously different film coefficients.

The over-all surface coefficient depends partly on the fluid but it depends also on the material of which the solid is made; also on the nature of the surface (rough or smooth); on its shape (with or without fins, etc.) and even on its "color" or spectral absorptance and emittance with emphasis on the infrared. A surface of a certain material may look black to the eye but may be a poor absorber of infrared; a surface of another material may be a perfect visual mirror but may poorly reflect infrared.

The ideal material would have extremely high heat conductivity, of course, but—and this is too often overlooked—it would "weigh nothing" (low density) and it would be "easy to heat" (low specific heat). Thus the ideal material would have an extremely high THERMAL DIFFUSIVITY—which all-important property is conductivity divided by (density times specific heat) or, in the usual symbols, $\alpha = k/pc$. Diffusivity may also be thought of as heat conductivity divided by heat capacity per unit volume. Remember that diffusivity is the most important thermometric property of sockets, etc., for upon its value depends the speed with which a temperature wave travels by conduction.

Case 1 is the Newton-Harper law. It is shown in the lower right-hand corner of Fig. 5. The top line of the 1″ square represents the initial temperature along a diameter (any diameter) of the sphere. It is the same as that of the furnace and it is absolutely uniform. It is not marked but the reader will note that it corresponds to no change: to 0% change. The cannon-ball is suddenly withdrawn and subjected to atmospheric temperature (100% change). The temperature of the cannon-ball drops according to the Newton-Harper law: at time 1.0 it has dropped 63% of the way. At that time—and at every other time—its center temperature is always the same as its surface temperature.

Such a cannon-ball does not exist. Why then are the departures of good commercial thermometers so small that complete response curves were represented as Newtonian? Because thermometer makers always did their best to use high-conductivity materials and, when using a poor conductor such as glass, made it so thin that its capacity (specific heat times density times mass) was so small that it almost acted as a "pure resistance" of smaller value than the reciprocal of the film conductance.

Surface film coefficients, by general agreement among writers on heat transfer, are devoid of capacitance. Their reciprocals are pure resistances. A film, in this sense, impedes the flow of heat as the flow of water is impeded by a cloth so thin that it does not absorb any water. Note in Fig. 2 that each film is responsible for a greater drop (or rise) than is the partition between air and medium. This Fig. 2 partition, by the way, is made of a poor conductor, as is evident from the ratio of the drops. When an excellent conductor separates warm stagnant air from cold stagnant air, its resistance is so small in comparison to that of the two films that its thickness may be that of tissue paper or that of a book without affecting the over-all transmission by more than about 0.3%. But the resistance of a sandwich consisting of a mica sheet between two 1″ metal plates may be a hundred times that of a 2″ (or 4″) metal slab.

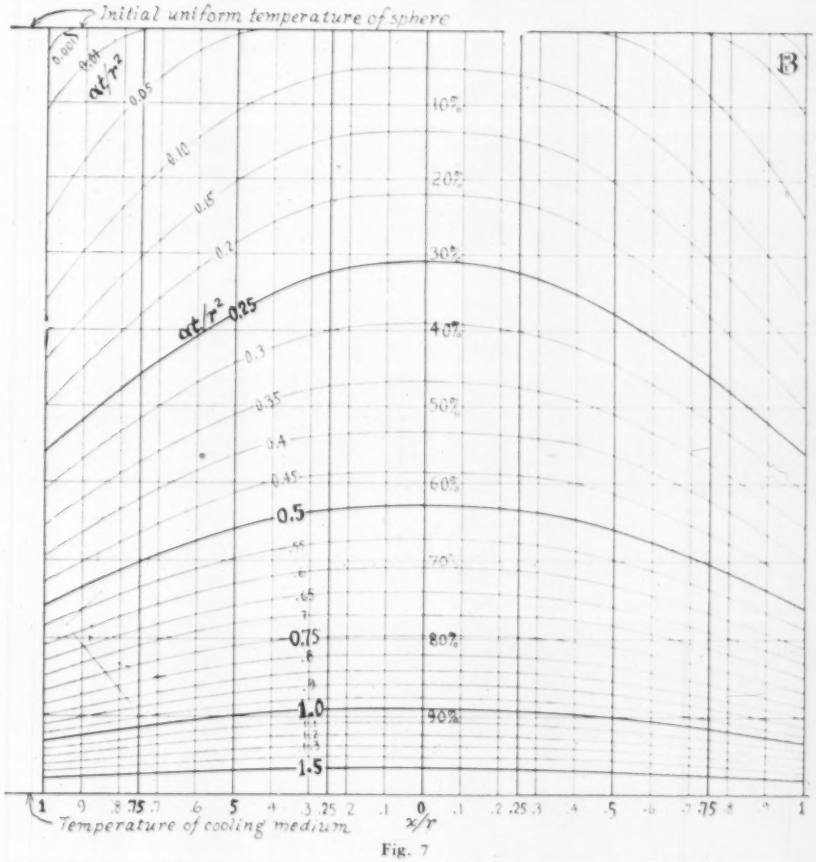


Fig. 7

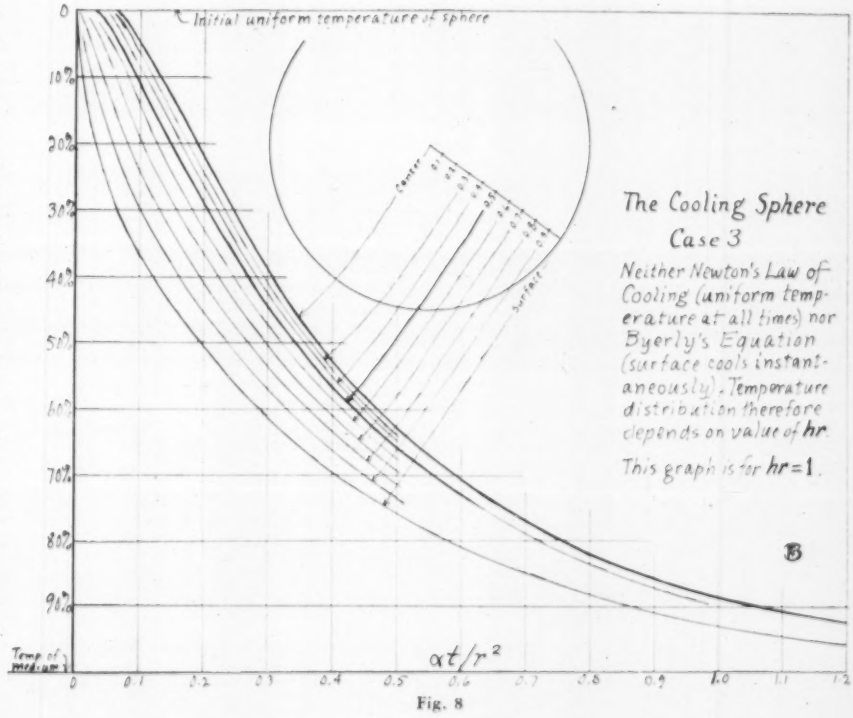

Initial uniform temperature of sphere
Center
Surface
The Cooling Sphere
Case 3
Neither Newton's Law of Cooling (uniform temperature at all times) nor Byerly's Equation (surface cools instantaneously). Temperature distribution therefore depends on value of hr
This graph is for hr = 1.
B
Temp. of medium
αt/r²

Fig. 8

Now for the other extreme, Case 2, where it is assumed that the body is suddenly immersed in a perfect medium so that the film conductance is infinite (film resistance zero) and, therefore, that the surface temperature undergoes a 100% change instantly. Figs. 5 and 6 illustrate the ensuing temperature history of every point within the sphere, thanks to the ingenious mathematics of Byerly and Williamson and Adams which made it possible to plot with "dimensionless time" for the time scales.

The nomenclature is included in Fig. 6. The c.g.s. system of units should be used in applying these two graphs to practical problems; but only when the reader is certain that film resistance may be ignored, as in heating or cooling a low-diffusivity body of fairly large dimensions in well-circulated water or other good heat-transfer medium. Our example, lower left corner of Fig. 5, is not a good one: sphere is too small.

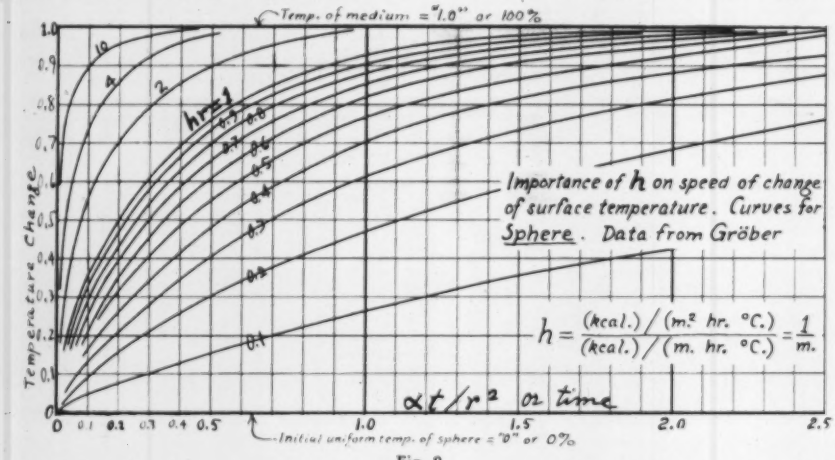

Temp. of medium = "1.0" or 100%
Temperature change
hr=1
Importance of h on speed of change of surface temperature. Curves for Sphere. Data from Gröber
h = (kcal.)/(m.² hr. °C.) / (kcal.)/(m. hr. °C.) = 1/m.
αt/r² or time
Initial uniform temp. of sphere = "0" or 0%

Fig. 9

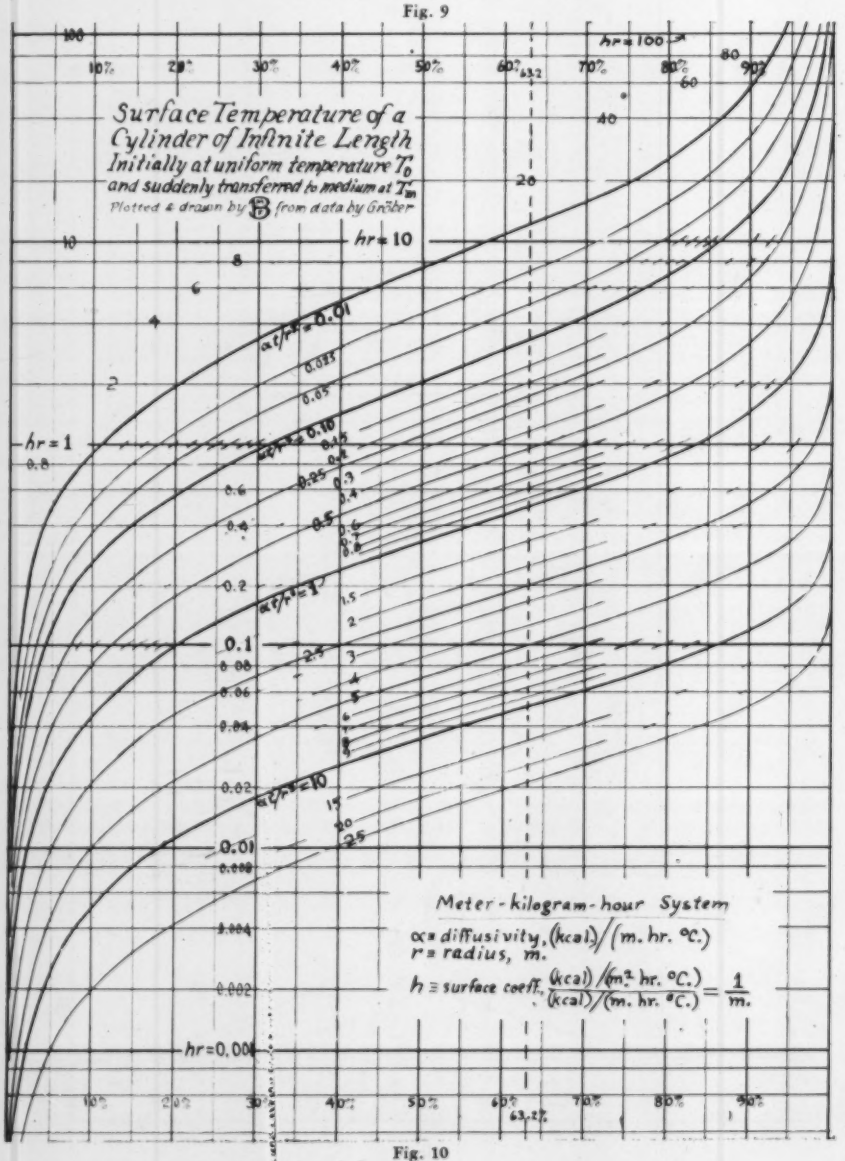


Fig. 10

Case 3 represents a close approach to actuality: the temperature history of every point within the sphere depends on the material and on film coefficients. From the voluminous literature, we chose the writings of Heinrich Gröber because he derived his equations with the use of an ingenious over-all surface coefficient h which he called *relative Warmeubergangszahl*. As explained in Fig. 9, this is the ratio of film coefficient (more a property of the medium than of the solid) to conductivity (of the material of the body). It being a reciprocal length, the lines in Fig. 7 converge at $1/h$ meters from the surface. Figs. 7 and 8 are plotted for $hr = 1$; Figs. 9 and 10 give usable data for other values of this product. Readers can use them by looking up values of film coefficients, etc. (and converting to m.k.s. and °C. from tables in American texts).

(Graphs for other bodies than spheres are generally similar at the start.)

To sum up: the Three Cases apply where the relative properties and sizes of bodies and the coefficients, are as follows:

Case	1	2	3
Size	small	large	any
Conductivity	high	low	any
Specific heat	low	high	any
Density	low	high	any
Film coefficient	low	high	any
Over-all surface coefficient	low	high	any

So far, only the sudden change has been discussed. A good deal of repetition would be required in connection with what happens at various points within a simple body when it is subjected to a square wave or to a sinoidal change of temperature. The theoretical essentials are all set forth graphically in Figs. 11 to 15. That these five drawings "speak for themselves" has been proved by audience reactions when they were shown as lantern slides. Consequently, the only textual comments which it seems proper to make are the following:

Figs. 12 and 13 show that the heat capacity of protection tubes, sockets, etc., may cause serious delayed starts.

Figs. 14 and 15 show, furthermore, the possibility of complex structures causing the controller to take aggravating action instead of corrective action.

These five figures, added to Figs. 5-10, show that incorporating derivative, automatic-reset, etc., in automatic-control instruments cannot fully remedy the harm done by the delayed start.

The delayed start is not serious in small one-piece elements and may be neglected in the new post-war primary-element assemblies with a thin-glass or conductive-metal bulb, or with good thermal contact between thin glass and metal well, or with EXCELLENT metal contact between metal bulb and metal socket, or (in the case of resistance thermometers) with a complex structure of the tiniest commercially-practicable outside diameter, or with only one "modern refractory material" thermocouple protec-

tion tube of MINIMUM commercial thickness. But many old assemblies still in use should be scrapped if really close control is desired.

Regardless of medium or circulation, each element has an INTRINSIC CHARACTERISTIC TIME: geometrically, the stubby cylinder is almost as slow as the sphere, the "ribbon" is the fastest; structurally, the fastest is the "one-piece" or "no-voids"; the slowest has dead-air spaces.

RECORDING RESPONSE CURVES

About ten years ago, when the suspicion that the delayed start and delayed end were not exceptional phenomena had become a certainty, several key men were tactfully approached. Their usual reply was: "These effects must be negligible; if they amounted to anything we'd have spotted them with the modern testing faciilties that you've admired!"

Remembering those high-precision calibration facilities, one did not insist. Later, one began to realize that such facilities alone did not suffice.

When war broke out overseas and America's national defense effort began, one brought up the subject again—still privately but to more and more men; and with modest suggestions for simple, inexpensive gadgets. Then came Beck's partial disclosure* in 1940 which unloosed other disclosures** of departures from the Newton-Harper law. Then came Pearl Harbor: appropriations for instrument purchases shot up high enough to defray the costs of the new research suggested to large users as well as to large makers. The gist of these recommendations was as follows:

First and foremost. Calibrating facilities, no matter how highly perfected, are designed for static or steady-state phenomena—bringing the thermometric system into temperature equilibrium with the medium or the source.

Second. Therefore, many respected traditions must be forgotten and attention must be centered on means for dynamic testing—not only for determining L_{63} but for recording the COMPLETE response curve.

Recording the INSTANT of t_0 is required for determining L_{63} of FAST elements.

And the common practice of "determining" t_0 by drawing a pure exponential backward from mid-curve test-points is absurd: IT DENIES THE EXISTENCE OF THE DELAYED START IT CONCEALS!

Among the recommended means were:

1. Constant-temperature baths and furnaces; and Standards for measuring such constant temperatures (all of which had previously been highly perfected). It is realized that salt baths and oil baths are costly and that wastage must be minimized in adapting them for response-curve research.

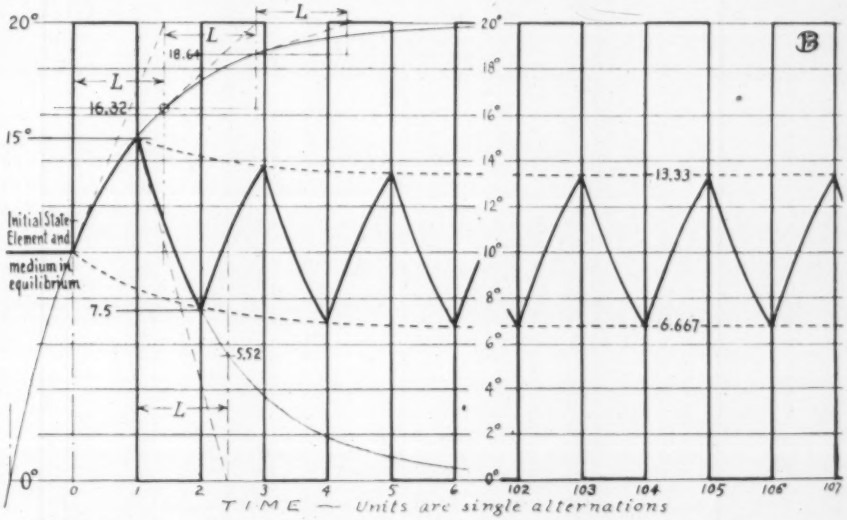
2. Sources of "expendable" controlled-temperature gases, liquids and radiations—all as inexpensive as possible.

3. Means for quickly transferring a primary element from the air to a bath or from one bath to another without undue waste of liquid or mixing the two liquids.

4. Means of subjecting an element to one transient or to a recurrent alternation (square wave) without mixing more than negligible amounts—which means continuously returning the hot stream to the hot tank and the cold stream to the cold tank.

5. Means of subjecting an element to a uniformity-changing temperature in order to determine the "true" or as-per-definition lag coefficient. Three principal types: (*a*) a pre-calibrated mixing valve of high precision, whose outflow is "wasted" in the sense that it must again be brought to temperature; (*b*) a long trough containing a syrup or other rheologically-suitable "stay-put" medium heated to uniform variation in SPACE so that traveling a bulb in TIME will produce the required effect; (*c*) a uniformly-rising-temperature bath—mentioned last because adequate linearity requires the refinements and costs of the highest-precision calorimeters, plus other features.

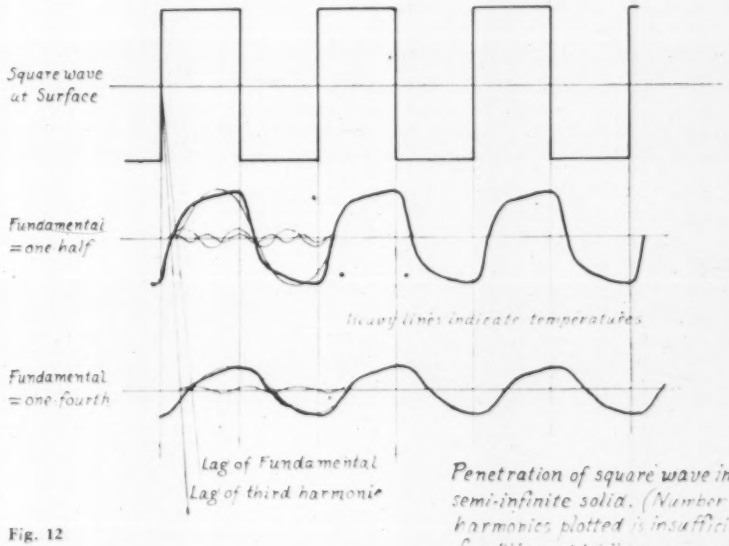
6. Means of subjecting an element to a sinoid. (*a*) Same as 5*a* but with the stem actuated by an eccentric or cam instead of



Response Curves of Primary Elements Obeying Newton's Cooling Law

Case No. A thermometric body possessing perfect conductance (so that its own temperature is always **uniform**), *surrounded by a pure resistance, subjected to a "square-wave" fluctuation of Period = $2L_{50}$.*

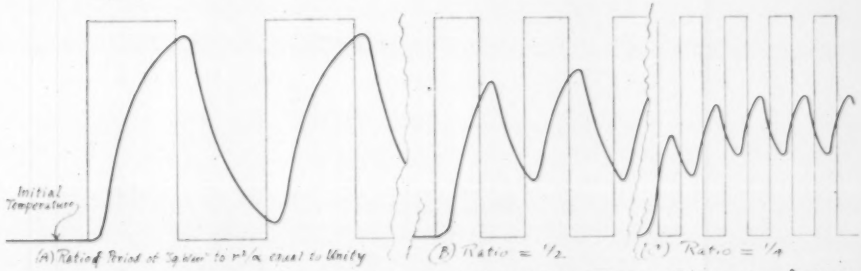
Fig. 11



Penetration of square wave into semi-infinite solid. (Number of harmonics plotted is insufficient for "line width" accuracy.)

Fig. 12

Fig. 13



Temperatures at axis of Cylinder ($\frac{r}{r_0}$ relatively low) whose surface is subjected to "square wave" temperature fluctuation

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*Rudolf Beck, "Thermometric Time Lag," *Transactions ASME*, 1941, pages 531-538.

**Discussions of Beck's paper, *ibid*, pages 539-543;

M. F. Behar, "Time—Automatic Control's Friend and Foe," *Instruments*, May 1941, pages 123-136. (See pages 130 and 131.)

M. J. Zucrow, "Thermometric Lag Determinations for Cylindrical Primary Elements," *Instruments*, Oct. 1942, pages 398-402, 442.

Bradford Noyes, "The Stem Lag of Industrial Thermometers," *Instruments*, Nov. 1942, pages 449-457, 492.

by a quick-shift device; (*b*) similar to 5*b* but circular instead of straight and with heat "tapering" on both sides of a diameter.

7. In connection with most of the foregoing, means of accomplishing sharp suddenness of temperature changes—approaching the ideal of the "instant."

8. In connection with most of the foregoing, means of recording the medium's temperature with extreme precision: bare fine-wire thermoelectric or resistance elements, or thin-foil thermistors, actuating oscillographs or high-speed recorders.

9. In connection with most of the foregoing, means of controlling the relative speeds of the medium and of the element—holding this speed constant when so desired—and always measuring it accurately whether it is the medium that flows or the element that moves in the medium.

10. In connection with ALL of the foregoing, means of recording AUTOMATICALLY the response curves. Above all, more accurate recording! In the past, those workers who reported departures from the simple Newton-Harper law had been able to do so because they used more accurate methods than had their precursors. Therefore, since today it is possible to measure a thousandth of a degree "here" and a millionth of a second "there," let previously-separate methods be combined.

It was known that several instrument companies had for years been aware of the NEED for faster elements and had brought out faster elements to anticipate the WANTS expressed by only a few prominent users. But it was hoped that the suggested intensive research, based on high-precision recording, would bring to light insuspected causes of slowness and delayed starts and would lead to the development of much faster elements and also to the improvement of installation conditions—including the improvement of processes.

These recommendations were supplemented by sketches of devices designed to put an end to "guesstimating" in lag tests by making possible for the first time the accurate recording of real response curves — particularly of that enemy of close control, the delayed start. Some of these old sketches are reproduced—all for the first time (except Fig. 21 which was printed in 1944). It is possible—or probable—that in the years since these (and other) sketches were privately recommended, several companies and institutions designed and built better ones; but inasmuch as they have not published their designs or even (to the best of our knowledge) disclosed the fact that they have installed high-speed high-precision dynamic-test facilities, these mostly-crude inventions are published for three purposes:

1. Openly propagandizing for the widespread installation of devices for recording response curves—not necessarily like these but taking many different forms according to the needs of each company or institution.

2. Coyly inviting all those who "built better mousetraps" to tell the world.

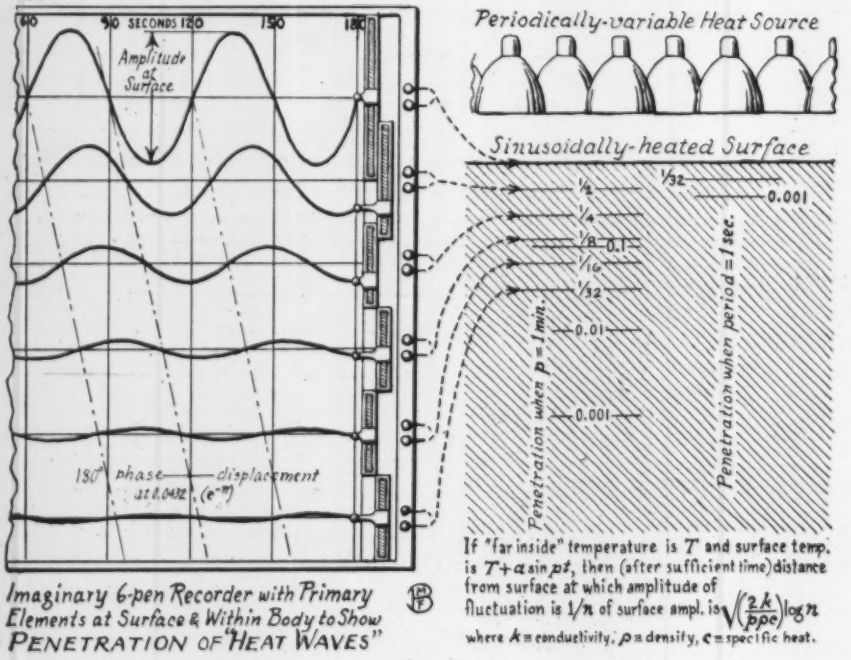
3. Stimulating the inclusion of ADEQUATE response data in specifications.

(It is no longer a purpose to stimulate the development of much faster elements; several instrument companies began intensive development programs immediately after Pearl Harbor and their greatly-improved products have been brought out.)

One recording essential will be mentioned first, because it was entirely overlooked by some of the men with whom the author discussed these tests some years ago. It is an ACCURATE synchronizer or time marker—and by "accurate" is meant that the error of recording the instant of the sudden change must be about one-thousandth of the thermal element's L_{63} or other comparatively-long characteristic time. Otherwise, the "delayed start" cannot be measured—cannot even be detected if the synchronizer is a last-moment makeshift. A mark must be made on the chart or film—whether by mechanical, electrical, optical or combination means—to show the EXACT time of the sudden change. No drawings of synchronizers or time-markers are included: they would take too much space and would only amuse readers who worked on certain military projects.

For square-wave and sinoidal-change tests, the importance of a synchronizer is arguable because, as a rule, the phase difference can be computed from the attenuation. What is most important is to calibrate the input amplitude on the same chart or film. To be sure, a good mathematician could compute the input amplitude from a series of records made at several speeds (like Fig. 13) but why go to needless tedium and trouble? Investigators can obtain the information wanted by merely inspecting the records of square-wave tests. A glance at the three 'scope pictures in Fig. 22 will show that a simple and reliable apparatus for producing square-wave inputs and recording the response curves can obviate the need of computations. It's the same idea as used in Inspection Departments where semi-skilled operators accept or reject parts by observing curves on 'scopes. But, just as the initial settings in an Inspection Department must be made by a professional in order that the curves should tell the truth, so must the two temperatures be marked accurately on the scale of the paper chart, or photographic film or paper, or 'scope screen. This takes time: the bulb or couple should be kept at each of the two extremes for at least ten times as long as L_{63} (because of the possibility of an unsuspected "delayed end") before starting a square- or sine-wave test.

The recording of response curves is not much of a problem in the testing of pressure-spring systems of recorder-controllers; the principal modifications are (1) substitute a fast chart-drive for the standard clockwork; and (2) install an accurate synchronizing device. The system's own pen will trace the response of the COMPLETE system consisting of bulb, capillary, pressure-spring and pen. Therefore, pen friction, tubing lag and other effects will make the response slower than that of the bulb alone—which is all to the good when the response of the complete measuring system is what is desired to be known, as in doing research on all the factors of a controller-and-process pilot plant where the process dead-times are supposed to have been minimized and where controller dead-time is suspected of being the chief culprit. In such a pilot plant, therefore, one should


Periodically-variable Heat Source
Sinusoidally-heated Surface
Amplitude at Surface
180° phase — displacement at 0.042 ($e^{-\pi}$)
Penetration when p = 1 min.
Penetration when period = 1 sec.
1/32
1/2
1/4
1/8
1/16
1/32
0.1
0.01
0.001
0.001
If "far inside" temperature is T and surface temp. is T+α sin pt, then (after sufficient time) distance from surface at which amplitude of fluctuation is 1/n of surface ampl. is $\sqrt{\left(\frac{2k}{ppc}\right)}\log n$
where k = conductivity, p = density, c = specific heat.

Imaginary 6-pen Recorder with Primary Elements at Surface & Within Body to Show PENETRATION OF HEAT WAVES"

Fig. 14

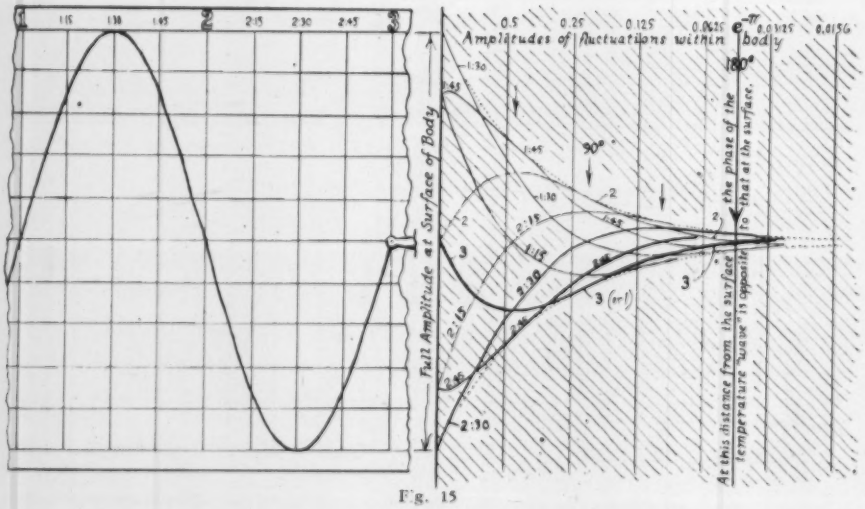

Amplitudes of fluctuations within body
Full Amplitude at Surface of Body
At this distance from the surface the phase of the temperature wave is opposite to that at the surface.
180°
90°

Fig. 15

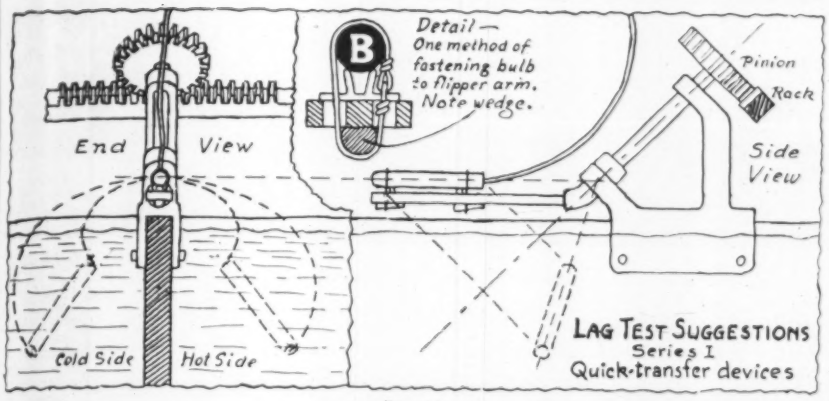


Fig. 16

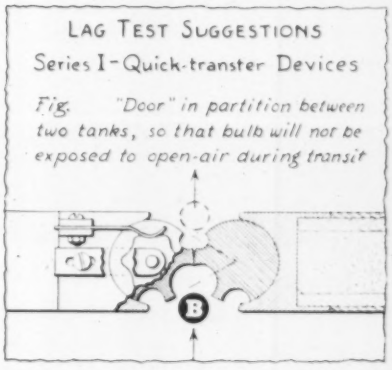

LAG TEST SUGGESTIONS
Series I - Quick-transfer Devices
Fig. "Door" in partition between two tanks, so that bulb will not be exposed to open-air during transit
B

Fig. 17

be careful to duplicate the installation conditions of the future application, including, of course, the tubing length.

The tubing lag coefficient may be of the order of seconds (not milliseconds) for each 100 feet. In the April 1941 *Instruments* Dr. H. A. Rolnick gave the following figures for L_{63} (no doubt too high for the improved models of today):

Type	*Tubing I.D.*	*Seconds*
Gas-filled	0.018"	0.5
Gas-filled	0.008"	13.0
Vapor-pressure ...	0.018"	84.0
Mercury	0.008"	4.0

Similarly, if the control parts carried by the pen are suspected of imposing a slight drag, they should not be removed; and it may even be advisable in some cases to run comparative tests with these parts functioning and not functioning. For example, if the pen carries a pilot valve flapper or lever, or a resistor-wiping arm, or even a non-contact device, an excellent way of determining the presence or absence of reaction or drag effects is to run tests with the electricity or fluid medium "full-on" and "all off." (Note: In most of the new models of air-ops, even those with flappers, the effect is negligible, but in many old models you can make the pen move—slightly but noticeably—by varying the air-supply pressure; and in some VERY old models you could "make the pen jump" by turning the air on and off. Don't laugh: these pioneer recorder-controllers made history!)

Recording the response curves of the measuring systems of non-recording (and non-indicating) controllers involves more time and perhaps some small extra expense, but it should involve neither "trouble" nor brain-racking in a large or medium-size Instrument Department. If the measuring system's indication or signal is electrical, the requisite facilities are no doubt at hand. If the indication or signal is the small deflection of a mechanical part, a piece of incombustible and non-curling foil can be attached to the arm or lever and the shadow of a selected edge projected on a moving film, photostat paper, etc. If optical magnification alone is depended upon, the blurred-edge uncertainty error may be commensurate with the desired limit of experimental error; therefore the foil you glue onto the deflecting member should be shaped like a lever to multiply the thousandths-of-an-inch deflections about twenty times so that the blurred-edge error will be much smaller than the least deflection to be shadow-recorded.

Some Gadgets

The first sketch, Fig. 16, is not a genuine invention: most of the credit should go to the late well-beloved Frank Bast who devised an automatic "flip-flop" for making weeks-long fatigue tests of mercury-system pressure-springs in 1922 or 1923, when a new steel analysis was specified and various heat-treatments tried out. Good old Frank gave the world an "everlasting" thermal system but he never recorded a response curve as now understood. His service-life tester allowed much too long an interval for the changes to be "sudden"; therefore the idea in designing the Fig. 16 device was to speed up the transit. The user should increase transit speed to near the danger-point of damage, especially in single-change tests requiring time-scale accuracy.

Notes: (1) In using all such devices, the bath circulation speed must be accurately known and jotted down. (2) The initial rapid immersion is equivalent to extremely rapid circulation; therefore the bath must have equally good circulation, so as to obviate the need of tedious computations of corrections for variations in the film coefficient of the outer surface. (3) This device is for relatively short bulbs; in long bulbs—say 18" or 24"—the centrifugal force, especially on mercury fillings, would produce a pressure wave serious enough not only to show one false jog on the record but to have a longer-lasting influence. (4) Splash guards cannot completely prevent mixing.

The Fig. 17 arrangement is one of several "through-the-wall" devices designed for three purposes: (1) to minimize the transit time of long bulbs which cannot be jumped over a partition; (2) to minimize splashing; (3) to determine the responses of bulbs which are to be installed in slowly-circulated media and which, therefore, are desired to be subjected to relatively slow circulation: accomplished by minimizing the distance.

Note: It is difficult to conceive a lag test reproducing stagnant-medium installation conditions: if the CHANGE is sudden, the circulation is momentarily rapid; if the

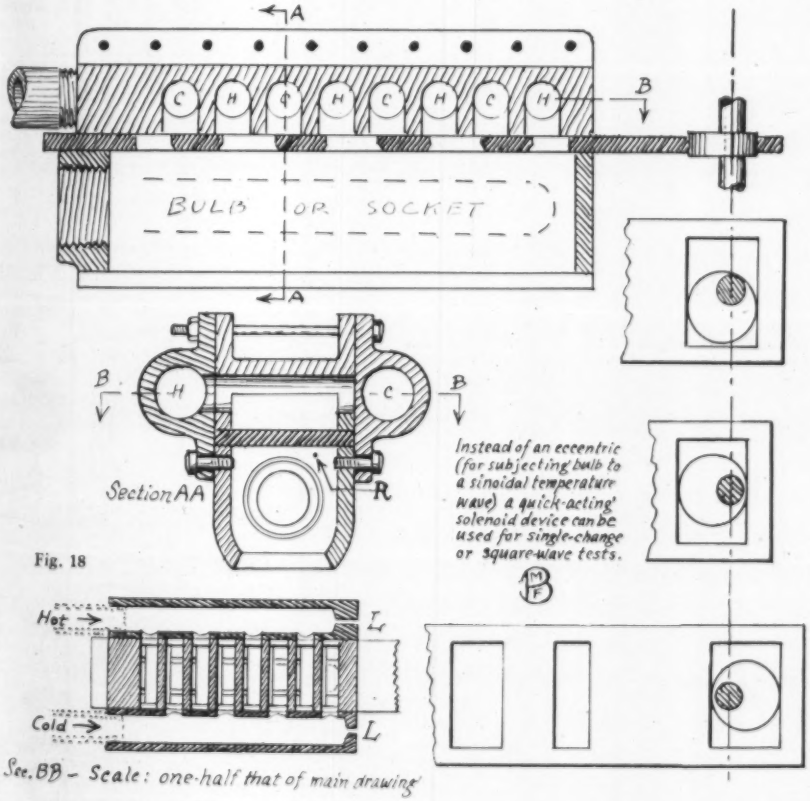

A
B
BULB OR SOCKET
Section AA
Instead of an eccentric (for subjecting bulb to a sinoidal temperature wave) a quick-acting solenoid device can be used for single-change or square-wave tests.
Hot
Cold
See BB – Scale: one-half that of main drawing

Fig. 18

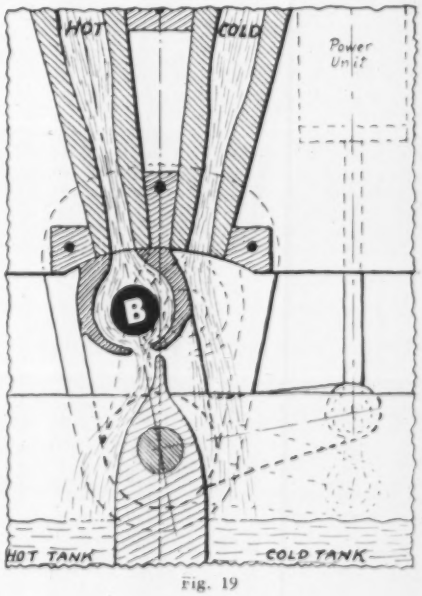


Fig. 19

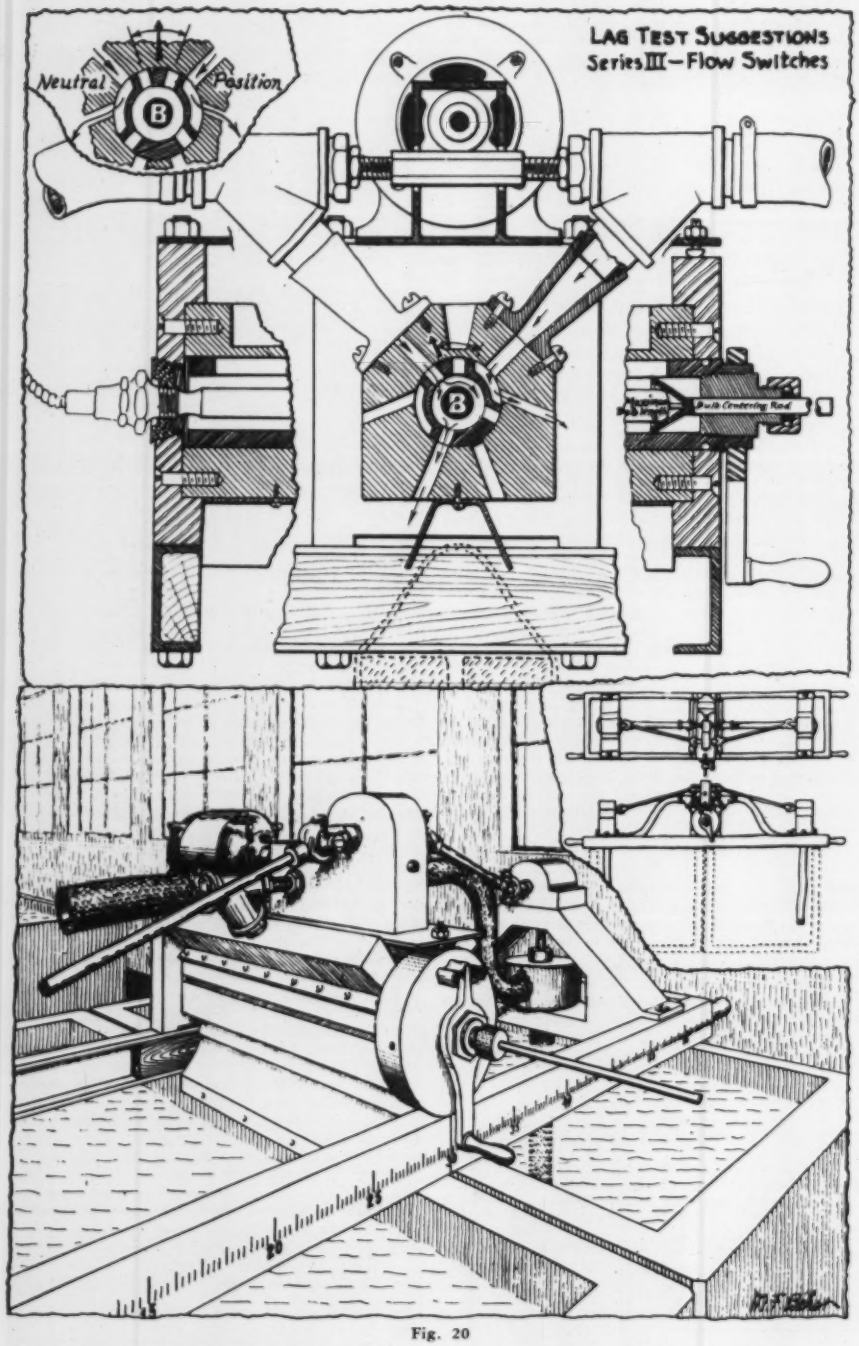


Fig. 20

change is slow, the recorded response curve is worthless because t_0 is unknowable..

Fig. 18 shows one of the multi-purpose devices for sudden-change, sinoid, square-wave, etc. Mixing is inevitable. The leaks *LL* prevent dead-ending a stream when it is momentarily shut off. A low-lag bare resistance wire, *R*, is the primary element of the chronograph and master recorder. Such a Standard should be incorporated in other devices when not shown in their drawings.

In Fig. 19 is shown one of several FLOW SWITCHES designed to accomplish a sudden change from one to another of two UNINTERRUPTED streams, each of which returns to its respective tank. The shortcoming is that the bulb is subjected to high accelerations at high speeds of switching.

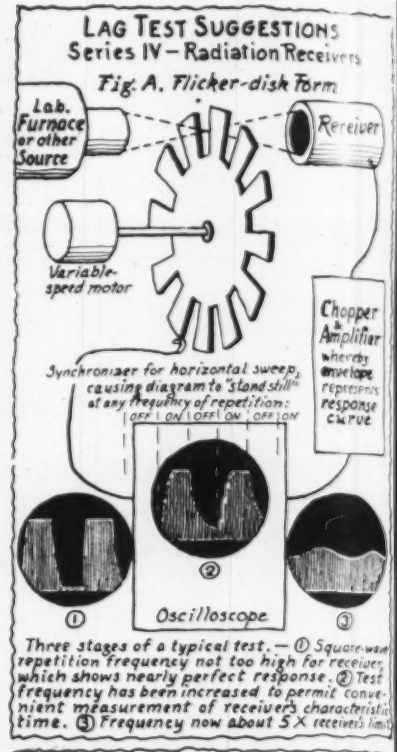
This shortcoming is overcome in the Fig. 20 device which holds the bulb motionless. The only moving part of this flow switch is the sleeve. Power shifter not drawn. To meet high-cost objections, the whole apparatus was designed to be easily transportable (see small sketch) so that a number of companies and institutions could use it in rotation and share the expense. (By the way, this could be done with other transportable devices.)

[Fig. 21 omitted at last moment for lack of space. It is the only lag-test apparatus drawing previously published. See *Instruments*, Nov. 1944, page 663.]

Fig. 22 is self-explanatory.

ACKNOWLEDGMENT

If the foregoing seems to be hortative and didactic (and even hypercritical in spots), the exact opposite—sincere admiration—is meant toward old associates and more recent acquaintances in Research and Development Departments who, though preoccupied with a thousand and one other problems, have for years made the continual reduction of primary-element lag one of their principal objectives; and to this sincere admiration is added a note of special thanks to all who, though at first unconvinced, lent moral support.


LAG TEST SUGGESTIONS
Series IV—Radiation Receivers
Fig. A. Flicker-disk Form
Lab. Furnace or other Source
Receiver
Variable-speed motor
Chopper & Amplifier whereby envelope represents response curve
Synchronizer for horizontal sweep, causing diagram to "stand still" at any frequency of repetition:
OFF | ON | OFF | ON | OFF | ON
①
②
③
Oscilloscope
Three stages of a typical test.— ① Square-wave repetition frequency not too high for receiver, which shows nearly perfect response. ② Test frequency has been increased to permit convenient measurement of receiver's characteristic time. ③ Frequency now about 5 X receiver's limit

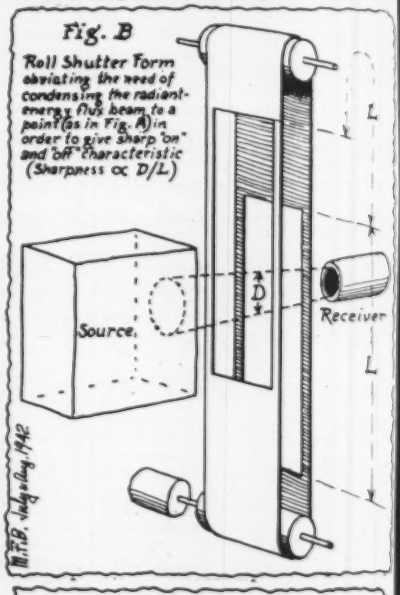


Fig. B
Roll Shutter Form obviating the need of condensing the radiant-energy flux beam to a point (as in Fig. A) in order to give sharp "on" and "off" characteristic (Sharpness ∝ D/L)
L
D
Source
Receiver
L
M.F.B. July-Aug. 1942

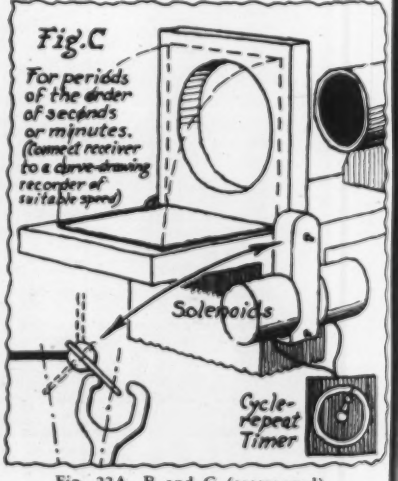


Fig. C
For periods of the order of seconds or minutes. (Connect receiver to a curve-drawing recorder of suitable speed)
Solenoids
Cycle-repeat Timer

Fig. 22A, B and C (rearranged).

THIRD ANNUAL CONFERENCE and EXHIBIT of INSTRUMENT SOCIETY of AMERICA

CONVENTION HALL, PHILADELPHIA, SEPT. 13-17, 1948

TECHNICAL PROGRAM

Instrument Society of America, American Institute of Electrical Engineers,
American Physical Society, American Society of Mechanical Engineers

MONDAY, SEPT. 13—10:00 A. M.

I.S.A. Session on Ordnance Instruments. Room 200. Technical Chairman, R. E. Hightower (Naval Research Laboratory, White Oaks, Md.)

"A Comparison of Small and Medium Electric Power Servomotors," by Robert S. Edwards (Sperry Gyroscope Co., Great Neck, L. I.) Paper No. 48-1-1.

Abstract. The paper will deal with the practical considerations of the various medium power servomechanisms. The qualities desired in such servomotors will be discussed and various types of servomotors compared. Specific data will be given for several motors.

"Photographic Instrumentation Used in the Development of the 'Bat' Missile," by H. K. Skramstad (Guided Missiles Section, Ordnance Development Laboratory, Washington, D. C.) Paper No. 48-1-2.

Abstract. A description is given of the various photographic instrumentation methods that were used during the war in the development of the guided missile "BAT." A film and slides showing the instrumentation of test vehicles to obtain data on aerodynamic performance, stabilization, and control during flight are presented.

"Temperature and Pressure Measurements in Rockets," by R. J. Havens (Naval Research Laboratory, Washington, D. C.) Paper No. 48-1-3.

Abstract. Ambient pressures in the upper atmosphere were measured by locating pressure gages in the nose, in the warhead and six diameters from the nose of a V-2. Pressures between atmospheric and 10^{-6} mm of Hg were measured. Bellows gages were used between pressures of one atmosphere and 30 mm of Hg. A series of Pirani gages were used between 20 mm and 10^{-3} mm of Hg, while a Philips gage was used to measure pressures between 10^{-3} and 10^{-6} mm of Hg.

Skin temperatures were obtained by using platinum resistance wires in thermal contact with the skin of the rocket. All temperature and pressure gages used in the rocket gave a change in potential of at least two volts over their useful range without the use of amplifiers.

MONDAY, SEPT. 13—2:30 P. M.

A.S.M.E. Session on Temperature and Pressure Elements. Room 200. Technical Chairman, I. M. Stein (Leeds & Northrup Co., Philadelphia, Pa.) Recorder, G. H. Lee (U. S. Naval Academy, Annapolis, Md.)

"Response Characteristics of Resistance Thermometers," by A. J. Hornfeck (Bailey Meter Company, Cleveland, Ohio.)

Abstract. Speed of response of the thermometer element is an important factor in the accurate measurement and control of temperature for industrial processes. This paper discusses the significance of the time constant as a basis of comparison of elements and shows quantitatively by means of data and curves the effects of varying the design factors such as socket size, materials and internal element structure. The relation between the heat transfer rate from the surrounding medium to the socket wall and the element response is shown by response data for a number of designs tested in air and water. Methods are given for determining the temperature vs. time response curves of elements in a medium whose temperature is changing suddenly, uniformly and sinusoidally as a function of time.

"Bourdon Tubes in 5000 psi Pressure Transmitters," by O. C. Brewster (Consultant, Litchfield, Conn.)

Abstract. Bourdon tubes, when the tips are restrained from motion, exert forces accurately proportional to the pressure applied, but these forces are relatively very small when compared with those of bellows or diaphragms of minimum practical area. Use is made of this characteristic in the design of a pneumatic force-balance pressure transmitter. The small force exerted by a high-pressure Bourdon tube results in a major reduction in the forces which the various parts of the instrument must withstand. As the balancing element an area baffle is used as this type of baffle has characteristics particularly well suited to this use. A 5000-psi transmitter was designed, built and tested. The entire instrument is housed within the case of a standard 4½" pressure gage.

MONDAY, SEPT. 13—8:00 P. M.

I.S.A. Session on Automatic Control. Ballroom.

"Demonstration of Automatic Control Principles," by Gerald F. Akins, assisted by John H. Kowalski (Eastman Kodak Co., Rochester, N. Y.)

Abstract. The problem of training new personnel in the fundamentals of Automatic Control was recognized as a plant-wide project in the Kodak Park Works of the Eastman Kodak Company. To provide this training it was decided that a visual demonstration of a control system such as a liquid level process would offer a most effective training device.

A portable panel depicting a "tank-level" process was constructed and a series of control "gadgets" ranging from the "on-off" type to the modern "proportional-reset-rate" type were fabricated on plywood panels for progressive use during the demonstration. The pattern of the lecture has been made to follow the stepwise improvements in controller design over the past twenty years.

To illustrate the proper application of a controller to a process, the basic panel can be arranged to allow for the addition of such factors as "demand capacity" and "time lag." To complete the picture, a typical drying process problem is discussed during the lecture to dramatize the "right" and "wrong" of controller application.

Following some forty demonstrations before varied groups such as engineers, staff technicians, installation men, instrument servicemen and production operators it is believed that the panel has been of considerable value as a training device since it greatly simplifies the explanation of a complex subject.

The panel was constructed by John H. Kowalski, supervisor of the Instrument Service Department at Kodak Park. During the demonstration, Mr. Kowalski assists the speaker by installing the various types of control mechanisms on the panel and making the necessary controller adjustments to suit the characteristics of the process.

TUESDAY, SEPT. 14—10:00 A. M.

I.S.A. Session on Control Valves. Room 200. Technical Chairman, Paul Elfers (Fisher Governor Company, Marshalltown, Iowa.)

"Valve Characteristics and Automatic Control," by J. G. Ziegler and N. B. Nichols (Taylor Instrument Cos., Rochester, N. Y.) Paper No. 48-2-1.

Abstract. This paper will discuss the operation and requirements of the control valve and its relation to the principles of automatic process control. An attempt will be made to relate the "control valve characteristic" to the other factors of controlability.

"Control Valve Body Design," by D. P. Eckman (Cornell University, Ithaca, N. Y.) and R. B. Werey (Conoflow Corp., Philadelphia, Pa.) Paper No. 48-2-2.

Abstract. The analysis of fluid flow through a control valve is approached from the viewpoint of inquiry into all of the factors influencing the calibration of the valve. It is said that a control valve is a calibrated device of simple construction and adequate capacity. The relation between hand valves and control valves is discussed and a very brief history of the control valve is given. Ideal flow conditions are given by the Bernoulli law and three difficulties with its use are reviewed. The influence of valve flow coefficient, loss coefficient, and form of pressure losses in valve bodies are considered; and a semi-analytical equation for actual flow through a valve is deduced. In part, it is concluded that extrapolation of valve flow data to high pressure differentials is fallacious and that maximum area of valve port opening should be proportioned to both valve entrance area and pressure differential.

"The Liquid Flow Characteristics of a Pipe Line and a Control Valve," by Otto Kneisel (Hammel-Dahl Company, Providence, R. I.) Paper No. 48-2-3.

Abstract. The object of this paper is to find the general solution of the following problem. If the following is known: the liquid flowrate in gallons per minute, the specific gravity, viscosity, the equivalent length of the pipe in feet, and the permissible line velocity, one can determine the pipe size, valve size, pressure drop required across the line and the valve, the flow rangeability and the flow characteristics. A general solution is derived and plotted on a network chart so that a given practical problem can be readily answered.

TUESDAY, SEPT. 14—10:00 A. M.

A.I.P. Session on Scientific Instruments. Room 300. Chairman, Gaylord P. Harnwell (University of Pennsylvania, Philadelphia, Pa.)

"Electron Microscopy," by James Hillier (Radio Corporation of America, Princeton, N. J.)

Abstract. The fundamental physical principles involved in the electron microscope and the basic design of a practical instrument will be discussed rather briefly. This will be followed by an evaluation of the present status of existing instruments both on the commercial and research levels. The range of application of the electron microscope will be described with a number of specific illustrations. Various limitations on the present application of the instrument will be considered in some detail and the methods by which these may be overcome will be discussed.

"The Measurement of the Particle Size of Sub-Sieve Powders," by R. E. Payne (Sharpless Corporation, Philadelphia, Pa.)

Abstract. A critical review of the more important existing methods of analysis of the particle size distribution of powders below the sieve range is given. In general, these methods are found to be inaccurate, tedious, and applicable to only certain types of powders. They possess a common difficulty in that no methods exist for the deaggregation and dispersion of general powder samples. A new method of gaseous sedimentation is described which is accurate, rapid, and largely free from these deaggregation and dispersion difficulties.

"Infrared Instrumentation," by Van Zandt Williams (American Cyanamid Co., Stamford, Conn.)

Abstract. A presentation of present-day infrared instruments such as prism and grating spectrometers, infrared gas analysers, and restrahlen equipment. The present day applications to infrared research, industrial analysis, and plant control will be discussed to furnish instrument criteria and to project future developments.

TUESDAY, SEPT. 14—2:30 P. M.

A.S.M.E. Session on Process Control. Room 200. Chairman, R. L. Goetzenberger (Brown Instrument Company, Washington, D. C.) Recorder, R. W. Hunting (Philadelphia Electric Co., Philadelphia, Pa.)

"Laboratory Anologs for Electric Furnaces," S. P. Higgins and R. M. Hutchinson, Brown Instrument Company, Philadelphia, Penna.

Abstract. Purpose of this paper is to demonstrate that analogs of electric furnaces can be developed from test data, which analogs will duplicate the action of the individual furnace insofar as on-off control is concerned. Pictures, analog diagrams, and descriptions are included on several furnaces and the method of development is demonstrated by calculations and data from one furnace.

Additional Papers to be announced later.

TUESDAY, SEPT. 14—8:00 P. M.

I.S.A. Session on Electronics. Ballroom.

"Looking into the Future of Electronics," Gordon Volkenant (Minneapolis, Minn.)

Presentation and demonstration will cover the unusual advantages of the "electronic way." A host of instrumentation applications will be covered, as well as facsimile, television, dust and dirt precipitation, electronic heating and cooking, metal and movement detection, radio control, electronic navigation, communication, etc.

WEDNESDAY, SEPT. 15—10:00 A. M.

I.S.A. Session on Cascade Controls. Room 200. Technical Chairman, Garner C. Parr (Ash Engineering Co., Philadelphia, Pa.)

"The Use of Interconnected Control Instrumentation for Offsetting Unfavorable System Characteristics," by J. A. Pellettere (Gulf Oil Corp., Pittsburgh, Pa.) Paper No. 48-3-1.

Abstract. An analysis of certain basic fluid-flow systems to assist in selection of instrumentation; a comparison of characteristics of one-, two-, and three-function instruments with the characteristics of a multiple, or interconnected, system of instruments in cases where unfavorable time lags exist.

"Experimental Application of Combustion Controls to a Process Heater," by W. E. Boyle (Shell Oil Co., Inc., Wood River, Ill.) and P. R. Hoyt (Shell Development Co., San Francisco, Calif.) Paper No. 48-3-2.

Abstract. Deals with the development, design, application and results of this experimental installation. Of particular significance is the successful application of an oxygen analyzer, measuring and recording oxygen content of the flue gas, used as an index for maintaining optimum combustion efficiency by automatically controlling flow rate of total combustion air. Improved combustion efficiency represents a reduction of fuel consumption averaging 15%. Based on this fuel saving payout time for the complete installation was 3½ months. Limitations emphasize need for improved burner and furnace design.

"The ABC's of Multi-Element Control," by C. H. Barnard (Bailey Meter Company, Cleveland, Ohio.) Paper No. 48-3-3.

Abstract. New approaches to control of continuous processes are necessary because of the trend toward higher through-puts and more precise operation. This paper covers the application of multi-element control systems to continuous processes, and discusses the benefits to be gained from their use. The various factors to be considered, and rules for application are given.

WEDNESDAY, SEPT. 15—10:00 A. M.

A.I.P. Session on Scientific Instruments. Room 300. Chairman, George R. Harrison (Massachusetts Institute of Technology, Cambridge, Mass.)

"The Physical Principles of Vacuum Measurements and Production," by C. H. Bachman (Syracuse University, Syracuse, N. Y.)

Abstract. The attainment of a vacuum in a chamber depends upon the diffusion of the undesired gas to an adjacent region of lower pressure. This region of lower pressure customarily is created by a vacuum pump or pumps operating either on the principle of mechanical positive displacement or on the basis of the undesired gas molecules being given a preferred directional impetus by the molecules of a controlled stream of vapor.

A number of phenomena exist by means of which the degree of evaluation may be measured. Each of these has its own range of usefulness. Control of pumps, valves, and associated apparatus may be obtained with some. Several new devices have been developed for use as gauges, indicators or for equipment control.

"Acoustics Instrumentation," by Richard H. Bolt (Massachusetts Institute of Technology, Cambridge, Mass.) and Richard K. Cook (National Bureau of Standards, Washington, D. C.)

Abstract. Acoustics measurements generally involve electroacoustic transducers for energy conversion; electronic equipment for energy generation, reception and processing; and, in many cases, special enclosures for producing specified sound fields. We describe first some precision transducers (microphones and earphones) which are used primarily as laboratory standard instruments. We then discuss some composite measuring instruments which combine transducers with electronic circuits. These include sound level meters and analyzers for audio measurements; and interferometers and pulsing equipment for ultrasonic studies of solids and liquids. Typical acoustic enclosure instruments are couplers for calibrating earphones and microphones; impedance tubes for studying acoustic materials; reverberation chambers for measuring absorption in surface materials and in the enclosed medium; and anechoic chambers for producing sound fields free from reflections.

"The Tools of the Physics Teacher," by Richard M. Sutton (Haverford College, Haverford, Pa.)

Abstract. Physics Laboratory experiments and lecture table demonstrations require a great variety of instruments, many of them designed in the past by those who discovered new principles or attempted to illustrate old ones. The need continually changes and new devices are called for. The author will evaluate some of the successful apparatus already available, will speak on the effect of new industrial materials on the tools of the teacher, will indicate some of the spots where improvements are needed, and will discuss the function of the physics teacher as a designer of new gadgets. The talk will be illustrated by demonstration of several experimental arrangements, in part the author's own creation, with the accent on simplicity.

THURSDAY, SEPT. 16—10:00 A. M.

I.S.A. Session on Control Instrumentation. Room 200. Technical Chairman, A. Novak (Monsanto Chemical Company, Boston, Mass.)

"Supervisory Control Systems," by Louis Gess and R. M. Hutchinson (Brown Instrument Company, Philadelphia, Pa.) Paper No. 48-4-1.

Abstract. Industrial processes have evolved into large complex units which instrumentation adds further complexity. Many fields are requesting condensed instrument panels to achieve lower cost, reduced operator fatigue, rapid manual response to upsets, and centralized authority. The authors present comments around the exhibition of a "future" panel by contractors and operators.

"Pneumatic Transmission Time Lags," by Mead Bradner (Foxboro Company, Foxboro, Mass.) Paper No. 48-4-2.

Abstract. Data are presented on the characteristics and values of lags encountered with ¼" and ⅜" copper tubing in lengths up to 2000 feet, using "infinite capacity" inputs which were varied by (a) step upset, (b) constant rate and (c) sinusoidal change. A number of termination volumes were used.

"Instrumentation—By and With Controlled Volume Pumps," by Robert T. Sheen (Milton Roy Company, Philadelphia, Pa.) Paper No. 48-4-3.

Abstract. The controlled volume pump is described as a meter with the elements of design that qualify it for this classification. The application of this type of pump with flowmeters is described for proportioning control. The pump is used with pH control systems with variables separately introduced on speed and on length of stroke so that two variables can be independently compensated affecting the rate of chemical fee.

A new system for concentration control is described. This system makes possible for the first time, control of concentrations where direct measurement of pH value, conductivity, specific gravity, etc. is not feasible or practical due to the relatively strong concentration resulting in a flat curve measurement. Specific examples of such concentration control are described with strong acids, strong alkalis, and the control of bleach baths by oxidation potential titration. A modification of this same general system is possible to give a continuous titration recorder.

THURSDAY, SEPT. 16—10:00 A. M.

A.I.P. Session on Scientific Instruments. Room 300. Chairman, Elmer Hutchisson (Case Institute of Technology, Cleveland, Ohio.)

"Radio Spectroscopy," by Charles H. Townes (Columbia University, New York, N. Y.)

Abstract. Use of radio-frequency spectroscopy has recently been increasing rapidly due, in large part, to the stimulus of microwave techniques developed for radar purposes during the war. This type of spectroscopy has been applied to a number of fundamental problems in the various fields of nuclear physics, molecular structure, and physics of the solid and liquid states. Techniques for measurement of resonant radio-frequency spectra as well as interpretation of the spectra will be discussed.

"Gas Analysis by the Mass Spectrometer," by Alfred O. C. Nier (University of Minnesota, Minneapolis, Minn.)

Abtract. When a gas at low pressure is bombarded by electrons positive ions are formed. These may be analyzed according to their weight by sending them through the proper combination of electric and magnetic fields. The method has become extremely useful as a method for analyzing mixtures of gases. Not only has it been employed in laboratory installations, but it has found a place in industrial control. Special instruments may be constructed which will monitor continuously the composition of a process gas. Other instruments based upon the mass spectrometric principle have been built for detecting leaks in apparatus which must be vacuum tight.

"Radioactive Tracer Techniques and Measurements," by L. F. Curtiss (National Bureau of Standards, Washington, D. C.)

Abstract. A discussion of the principles involved in use of radioactive tracers with enumeration of some typical radioisotopes suitable for special tracer applications. Methods of preparing labelled elements will be described with the details of the required measurements of the radioactivity of the samples. Some examples of the successful use of radioactive tracers will be summarized, particularly in the fields of physics, chemistry and biology.

THURSDAY, SEPT. 16—2:30 P. M.

A.I.E.E. Session on Electronic Instruments. Room 200. Chairman, R. Feldt (Allen B. DuMont Laboratories, Inc., Passaic, N. J.)

"Fail-Safe Operation of Electronic Circuits," by G. D. Hanchett (R.C.A. Mfg. Co., Camden, N. J.)

Abstract. An important consideration in the design of many electronic circuits for the control of industrial equipment is that the circuit must "fail-safe." The possible causes of failure with conventional circuits are reviewed, and the following types of failure are discussed in detail: 1. Those resulting from tube aging. 2. Those resulting from tube shorts or opens. 3. Those resulting from other component parts defects.

Methods for achieving "fail-safe" operation are examined and illustrated by basic circuits utilizing the type 2D21 and incorporating "fail-safe" design.

"Cathode Ray Oscillograph Developments for Laboratory and Production Use," by C. Berkley (Allen B. DuMont Labs., Inc., Passaic, N. J.)

Abstract. A recently developed series of cathode-ray tube instruments and accessories, enabling the satisfactory solution of the widest range of oscillographic problems are described. These include: 1. Standard high voltage oscillographs and power supplies for use in high speed photography and projection of patterns for educational purposes. 2. A High Voltage Cathode-ray Oscillograph Indicator and its power supply, capable of operation up to 29 kilovolts, for use in high speed transient studies. 3. A precision Cathode-ray Oscillograph developed for television wave form monitoring, capable of driven sweeps of 2-inches-per-micro-second writing speed and having a bandwidth of 10 megacycles. 4. A Dual Beam Oscillograph with completely independent control of both beams. 5. A continuously synchronized Polar Co-ordinate Indicator, developed for studies in connection with rotating mechanical systems.

Accessories to these instruments for calibration, projection, and photographic recording are described. Design features of these cathode-ray oscillographs indicating future trends are discussed. Typical applications are described and will be demonstrated during presentation.

"Oil Film Thickness Indicator for Journal Bearings," by Mr. M. L. Greenough (National Bureau of Standards, Washington, D. C.)

Abstract. An instrument is described for measuring the radial thickness of lubricating oil film separating a rotating shaft from its bearing. Four distance-measuring elements mounted on the bearing provide electrical signals proportional to film thickness at these locations. A cathode ray tube fed with these signals gives a continuous indication of eccentricity, the radial displacement of shaft center from bearing center. Provision is made for determination of diametrical clearance at any time during operation, permitting rapid determination of film thickness by subtracting eccentricity from one half the diametrical clearance. The necessary vectorial subtraction is performed by manipulation of suitable scales on the cathode ray tube screen.

The distance-sensitive elements, operating upon the principle of variation of mutual inductance with proximity of a conducting surface, are discussed in detail. Recent trends toward miniaturization of these elements are shown. Electronic circuit design and instrument performance are also treated.

THURSDAY SEPT. 16—8:00 P. M.

I.S.A. Session on Instruments in Crime Detection. Ballroom.

"Science in Crime Detection," by L. V. Boardman (Special Agent in Charge, Philadelphia office, Federal Bureau of Investigation, Philadelphia, Pa.)

Abstract. Outline of origin and growth of Technical Laboratory of the F.B.I., which is more popularly termed the Crime Laboratory, to where it is today the largest and best equipped crime laboratory in the world. Criminal case histories reflecting where items of evidence found at the scene of the crime were transmitted by the investigator to the laboratory for examination will be cited. Will explain the types of examinations which can be performed for the investigator by the scientist in the laboratory. Discuss firearms identification theory and conclusions which can be reached as a result of an examination of bullets, cartridge cases, etc.

Metallurgical examinations, tool marks, glass fractures, document examinations, how the spectrograph has been utilized in the fight against crime will be covered. Mention will also be made of hair and fibre examinations, toxicological specimens, blood examinations, reproduction of original evidence in the third dimension.

FRIDAY, SEPT. 17—10:00 A. M.

I.S.A. General Instrument Session. Room 200. Technical Chairman, E. D. Wilson (Worcester Polytechnic Institute, Worcester, Mass.)

"Flow Measurement of Gases and Liquids through Primary Elements in Pipe Sizes of Less Than Two Inches," by Henry W. Stoll (Taylor Instrument Cos., Rochester, N. Y.) Paper No. 48-5-1.

Abstract. Flow Measurement through primary elements does not lend itself to predictable mathematical expression when carried out in pipe sizes less than two inches. Instead, coefficient and separate exponents applicable to differential produced and absolute pressure are established through tests. Influence of these factors is shown on the accuracy of flow measurement as well as on flow integration and flow ratio installations.

"Instrumenteering — Trinket or Tool," by J. Johnston, Jr. (E. I. Dupont de Nemours Corp., Wilmington, Del.) Paper No. 48-5-2.

Abstract. Objectively this paper deals with the relative value of instrument engineering as a separately recognized department in the engineering organization of the instrument user.

Discussion will center on the coordination between such a group and the research, development, technical service, design, construction, operation, and maintenance departments of a given corporation. Attention will also be directed toward the machinery for cooperation with the other branches of engineering, the departments of accounting and purchasing, and the many phases of control required by Management. An attempt will be made to evaluate the variety of typical organizations in existence today, and in conclusion, the author will propose, what he considers to be, the most efficient type of organization for this work.

"The Development of Instrument Curricula," by M. B. Hall, (Foxboro Co., Foxboro, Mass.) Paper No. 48-5-3.

Abstract. There are three levels of Industrial Instrument Education; Instrument Mechanic, Engineering school undergraduate and Graduate school. The first involves a course of study at a level that will enable the individual to increase his knowledge and skill to obtain the maximum rating in remuneration and responsibility. The second should be at least a survey course to acquaint the engineering student with one of the important tools with which he will work in industry. The third should include a quantitative study of the fundamentals of process control involving a mathematical approach to the subject. Suggested curricula will be developed.

FRIDAY, SEPT. 17—2:30 P. M.

A.I.E.E. Session on Electronic Instruments. Room 200. Chairman, W. R. Clark (Leeds & Northrup Co., Philadelphia, Pa.)

"Resume of A.I.E.E. Conference on Electron Tubes for Instrumentation and Industrial Use Held in Philadelphia March 29 and 30," by W. R. Clark (Chairman A.I.E.E. Joint Subcommittee on Electronic Instruments.)

Abstract. It is apparent from the various discussions at the A.I.E.E. Conference on Electron Tubes for Instrumentation and Industrial Use, which was held in Philadelphia March 29 and 30 of this year; that long life and dependability of tubes are the most important factors. Reproducibility of characteristics between tubes is a close second, as far as the instrument manufacturers and industrial users are concerned. Continuity of supply is vital and notice of withdrawal of the tube ten years before withdrawal takes place would be of valuable assistance to the users. The discussions at the Conference checked in general, the results of the survey conducted by the A.I.E.E. during 1947. More pertinent facts concerning the Conference and the survey results will be discussed in detail.

"A Study of Slide Wire Contact Resistances," by W. E. Belcher, Jr., (Brown Instrument Co., Philadelphia, Pa.)

Abstract. With an arbitrarily selected set of physical dimensions, contact resistances against a wound slidewire were studied. Using a current of 5 milliamperes with a driving voltage of 1.5 volts, the force on the contact and the contact resistance were measured. Three contact materials, sterling silver, platinum, and paliney No. 7, and three slidewire materials, manganin, constantan, and nichrome V were used. Sufficient data were collected to plot curves of contact resistance versus force on the contact for the nine combinations of the materials.

"Development of Self Balancing Recorders," by A. J. Williams, Jr. (Leeds & Northrup Co., Philadelphia, Pa.)

Abstract. Over fifty years ago H. L. Callendar built a crude self-balancing recorder to measure temperature with his platinum resistance thermometer. The self-balancing principle has gained acceptance through the years as the development of self-balancing recorders has progressed. A few of the major steps in this development are described. Some limitations on currently popular types are discussed.

"Salinity-Temperature-Depth Recorder," by A. W. Jacobson (Bristol Co., Waterbury, Conn.)

Abstract. Data relating the temperature and salinity of sea water to position and time are essential to the study of oceanography. The paper describes a recording instrument which allows continuous measurements of these quantities to be made from a moving vessel. The instrument includes a network which computes the salinity of sea water from simultaneous measurements of temperature and specific electrical conductance. The theory and design considerations of the measuring and computing circuits are discussed. The design of a thermal element with high speed of response and capable of withstanding large hydrostatic pressure is described. There are included several charts of records obtained during hydrographic surveys in the Gulf Stream and in New England coastal waters.

Educational Lectures

for instrument men and apprentices, inspectors and shop men, metermen and others

ROOM 304

Subjects: Electrical Measurements and Industrial Instruments

DESCRIPTIVE LIST *of the* EXHIBITS *and* PERSONNEL *in* ATTENDANCE

Accuracy Scientific Instrument Co., Philadelphia, Pa. 411

Exhibiting: New flat-bore Senior Midget industrial thermometer with separable socket, straight and angle forms. Laboratory and industrial thermometers, thermostats, relays; hydrometers.

In Attendance: Charles G. Hinkle, Gen. Mgr.; Ernest W. Stiess, Supt.

Aeromarine Instrument Co., New York, N. Y. 516

Exhibiting: New diaphragm gages; differential pressure gages; switch gages; tachometer; compound electric alarm gage type 1002.

In Attendance: Matthew Forelli, V. P.

Aeroquip Corporation, Jackson Mich. 503

Exhibiting: New "Breakaway Coupling" automatic-sealing twin unit for connecting hydraulic lines. Flexible hose lines; detachable hose fittings; "Hydraliscope" at work.

In Attendance: L. S. Haynes, Jr., Sales Engr.; E. A. Nelson, Development Engr.

Aircraft Marine Products, Inc., Harrisburg, Pa. 232

Exhibiting: New foot-operated press for installing AMP solderless terminals; hand tools with safety device; pneumatic hand tools for assembly line installations; solderless replacement terminals for "snap in" disconnect connections. Solderless electrical wiring terminals and installation tooling.

In Attendance: Richard Renner, Phila. Dist. Mgr.; Joseph I. Simpson, Sales.

American Car and Foundry, Valve Div. New York, N. Y. 209

Exhibiting: Control valves.

In Attendance: Sheffler Gross Co., Philadelphia Representatives.

American Institute of Physics, New York, N.Y. 149

Exhibiting: Publications of the Institute; membership information and data on the member Societies: American Physical Society, Optical Society of America, Acoustical Society of America, American Association of Physics Teachers, Society of Rheology.

In Attendance: Henry A. Barton, Director; Cleveland Norcross, Asst. Dir.; Ruth F. Bryans, Publication Mgr.

American Instrument Co., Silver Spring, Md. 136, 138

Exhibiting: New electric hygrometer for precise indicating, recording, controlling of humidity. Electric heaters; electric regulators; electric relays; thermometer calibrating baths; constant temperature and humidity cabinets and controls; engineering service for constant temperature and humidity control.

In Attendance: W. H. Reynolds, R. C. Ohleiser, R. E. Hadady, L. R. Heiss.

American Meter Co., Philadelphia, Pa. 234, 236, 238

Exhibiting: New automatic flow controller. Recording orifice meter; recording and intregating flow-meters; pneumatic transmitter with controller receiver; wet and dry laboratory test meters; high-pressure observation meter; "Ironcase" gas meter; pressure and temperature compensating devices for positive-displacement meter; pressure-reducing regulator; relief valves; back-pressure regulators.

In Attendance: W. Kehoe, D. Wiley, Research Engrs.; R. Wilmarth, Asst. Mgr. Chicago Div.; R. Connors, Sales Engr., Boston; A. B. Clous, Sales Engr., New York; J. Gribbel, II, N. V. Howard, A. S. Chatfield, Sales Engrs., Philadelphia; J. Pruit, Sales Engr., Chicago; A. Costa, Sales Engr., Houston; B. McKalip, Sales Engr., Tulsa.

American Society of Mechanical Engineers, New York, N. Y. 529

Exhibiting: Books, standards, reports, special publications with emphasis on material contributed or sponsored by the Industrial Instruments & Regulators Div. of the Society.

In Attendance: Miss E. M. Murrayes, Pub. Sales Mgr.

Askania Regulator Co., Chicago, Ill. 427, 429

Exhibiting: New electronic position servo system, varying combinations of transmitter, amplifier and receiver to give accurate instantaneous remote control. Jet pipe regulators; transometer; straight and crank type cylinders.

In Attendance: H. J. Velten, Pres.; H. Ziebolz, V. P.; W. F. Pray, N. Y. Dist. Mgr.; H. K. Hicks, Dravo Corp.

Associated Research, Inc., Chicago, Ill. 210

Exhibiting: New "Vibroground" geophysical prospecting instrument; phase sequence indicator; Smith fluxmeter; compensated "Donut" current transformers. Insulation resistance tester; ground resistance tester; insulation breakdown tester; soil resistivity meter; low range limits bridge; AC voltammeter; current transformers; hand tachometers; Keeler polygraph (lie detector). Consultation service, repair and testing.

In Attendance: James F. Inman, Pres.; R. E. Holmes, Ch. Engr.; Robert O. Held, Special Project Engr.; John Gray, Linn O. Morrow, Robert Morroe, Sales.

Autoclave Engrs., Inc., Erie, Pa. 151

Exhibiting: New one-liter 3000-lb. standard autoclave; pressure intensifier 10-1 ratio, maximum pressure 100,000 lbs./in.^{2}. High-pressure valves and fittings; high-pressure autoclaves and reactors; high-pressure equipment for research and pilot plants; hydrogenation units.

In Attendances Fred Gasche, Pres.; Ralph Bergen, Mgr. Phila.; E. H. Epprecht, Sales engr.; Richard L. Berger, Sales Engr.

Automatic Temperature Control Co., Philadelphia, Pa. ..144, 146, 148

Exhibiting: New "Atcotran." Timers, time controls, vales and valve controllers; various types of relays. Specialty engineering.

In Attendance: W. W. Winters, V. P. Sales; G. B. Ebling, Sales Pro. Mgr.

Bailey Meter Co., Cleveland, Ohio 426, 428

Exhibiting: New smoke density recorder operated by bolometer type smoke detector; conductivity and pH recorder both recording on same chart. Pyrotron resistance thermometers and potentiometer; area type flow meter; recorders; steam flow-air flow boiler meter; oxygen and combustibles application engineering.

In Attendance: H. M. Hammond, V. P.; F. S. Dickey, V. P.; H. C. Tanner, Mgr., Philadelphia Office; C. H. Barnard, Application Engr.; A. J. Hornfeck, Res. Engr.; E. B. Bossert, Adv. Mgr.

Baird Associates, Inc., Cambridge, Mass. 506, 508

Exhibiting: New infrared gas analyzer redesigned for plant and laboratory applications. Spectographs; densitometers; spectrophotometers; interferometers.

In Attendance: S. H. Walters, Sales Mgr.; R. P. Mahan, J. M. Devine, Sales Engr.

Ballantine Labs., Inc., Boonton, New Jersey 410

Exhibiting: New sensitive electronic voltmeters.

In Attendance Frank R. Zayac, Gen. Mgr.; Edmund Osterland, Ch. Engr.; Russell Rogers, Engr.; Walter Knoop, Sales Engr.; A. W. Janes, Sales Engr.

H. Belfield Co., Philadelphia, Pa. ..436

Exhibiting: New full throttling diaphragm-motor valve; semi-throttling diaphragm-motor valve; duplex burner regulator; packless valve; springless diaphragm motor; rotary plug cock; displacement type liquid level controller; consulting service.

In Attendance H. L. Murray, Pres., F. R. Goehring, V. P.; E. Wolff, Ch. Engr.; F. M. Carroll, N. Y. Dist. Mgr.; T. L. Smith, Field and Sales Engr.; H. A. Frederick, Sales Engr.; J. Arbuckle, Sales Coord.; E. B. Myers, Ch. Designer.

James G. Biddle Co., Philadelphia, Pa. 214, 216

Exhibiting: New transformer turn ratio set for fault location in transformers; rectifier-operated "Meg" insulation tester. "Megger" insulation, ground and low-resistanec testers; "Jagabi" speed measuring instruments; "Jagabi" rheostats; "Frahm" resonant reed tachometers and frequency meters; "Pointolite" lamps; "Apiezon" oils and greases.

In Attendance T. B. Whitson, Engr.; E. E. Lauge, Engineer; A. Q. Lauge, Engr.; E. B. Curdts, Engr.; H. A. Eysenbach, Engr. A. F. Zell, Engr., C. S. Swan, Engr.; S. C. Sommer.

J. Bishop and Co., Malvern, Pa. 414

Exhibiting: Stainless-steel capilary tubing, small-diameter mechanical tubing; seamless and welded stainless steel, Monel, Inconel and nickel coils, bent, forged and special parts; platinum thermocouples; electrical circuit parts; bimetal strip, plate and tubing; resistance wires. Metallurgical and mechanical engineering service.

In Attendance: P. C. Kerk, Pres.; E. E. Comfort, Prod. Mgr.; W. H. Edwards, P. C. Kehoe, Sales; G. A. Hammond, Mgr. Platinum Dept.; Walter Colbert, Sales.

Brabender Corp., Rochelle Park, N. J. 134

Exhibiting Viscograph; plastographs; pressure thermometer; recording viscosimeter; semi-automatic moisture tester.

In Attendance: Arthur Hartkopf, Pres.

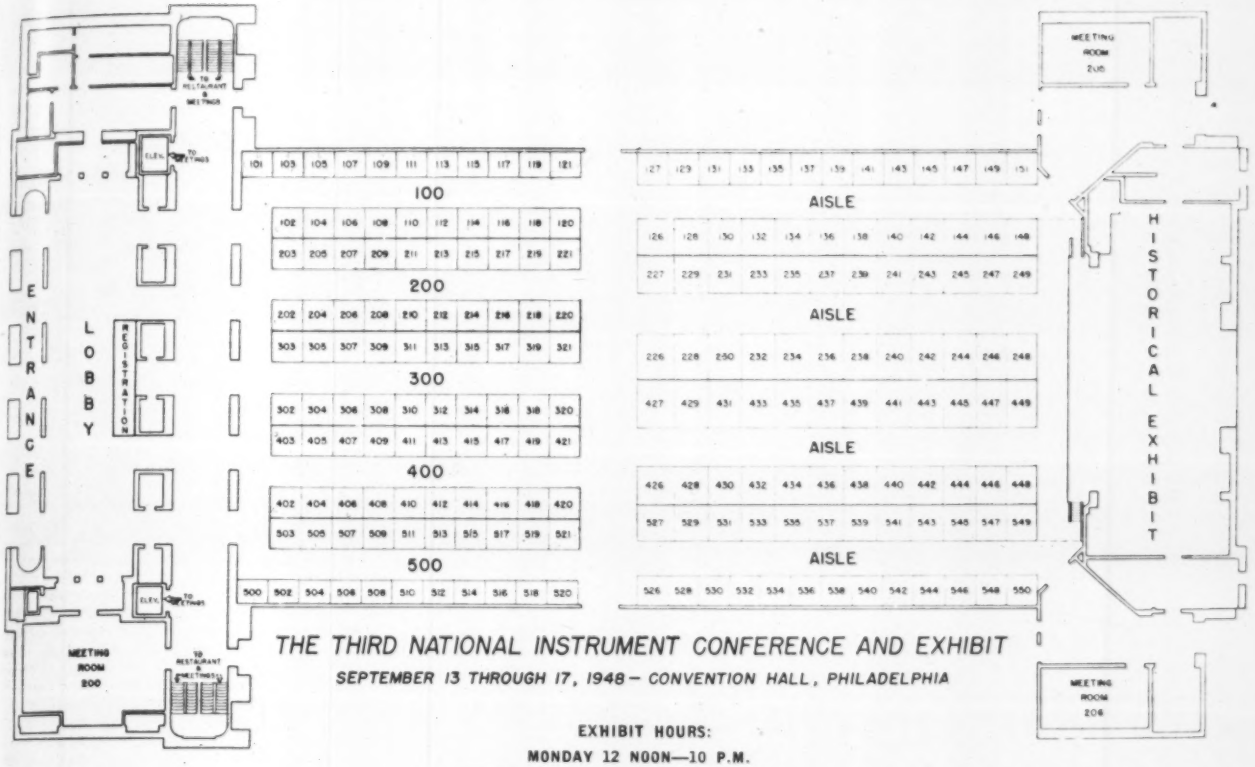
Branson Instruments, Inc., Dansbury, Conn. 518

Exhibiting: New coating thickness gage for non-magnetic coatings on steel and iron. "Audigage" thickness detector.

In Attendance: Norman G. Branson, Pres.; Peter B. Block, Sales Mgr.

Bristol Co., Waterbury Conn. ..218, 220

Exhibiting: New Series 500 air-operated control system; Series 500 wide-strip Dynamaster resistance thermometer; Series 500



THE THIRD NATIONAL INSTRUMENT CONFERENCE AND EXHIBIT

SEPTEMBER 13 THROUGH 17, 1948 — CONVENTION HALL, PHILADELPHIA

EXHIBIT HOURS:
MONDAY 12 NOON—10 P.M.
TUESDAY AND THURSDAY—2 P.M. TO 10 P.M.
WEDNESDAY AND FRIDAY—10 A.M. TO 6 P.M.

Metavane; pneumatic transmission system; Series 500 Process-cycle controller; bellow-differential flowmeter. Continuous pH controllers; Free-vane air-operated controllers; recording gages; recording thermometers.

In Attendance: H. E. Beane, Gen. Sales Mgr.; F. W. Borchers, Asst. Sales Mgr.; L. E. Mustard, Dist. Mgr. Phila.; G. H. Gaites, Dist. Mgr., N. Y.; H. C. Clark, Dist. Mgr. Pittsburgh; E. Huber, Mgr. Application Engineering; G. P. Lonergan, Mgr. Sales Promotion.

Ralph N. Brodie Co., Inc., New York, N. Y. 137

Exhibiting: New positive-displacement petroleum meters and accessories.

In Attendance: C. J. McCaffrey, Vice President.

Brooke Engineering Co., Inc., Philadelphia, Pa. 404

Exhibiting: New electric eye overfire jet control. Smoke indicators; combustion controls.

In Attendance: G. A. Brooke, Jr.; James S. Merritt, Walter D. Hoffman, Donald C. Spangler, Robert C. McNickle.

Brookfield Engineering Labs., Inc., Boston, Mass. 111

Exhibiting: Indicating viscometer, automatic viscosity controller; counter-rotating mixer; engineering development service particularly in viscometry.

In Attendance: G. W. Brookfield, Treas; D. W. Brookfield, Research Dir.

Brooks Rotameter Co., Lansdale, Pa. 142

Exhibiting: New "Inductronic" recorder-controller rotameter with electronic power; "Sho-rate" purge rotameter; "Stain-Met" high-pressure armored rotameter; "Ful-View" rotameter with safety shielding. Consulting service on flow rate measurement and control of liquids and gases.

In Attendance: S. A. Brooks, Pres.; Doug Brooks; Jack Lawrence, C. E. Barba, Horace Lemmer, Herb Barnum, Sales Mgr.

Brown Instrument Co., Philadelphia, Pa. 435, 437, 439

Exhibiting: New "Remote Set" compact units for remotely resetting flow, level pressure or temperature pneumatic controllers. "Electronik" potentiometer pyrometers and resistance thermometers; flow meters; thermometers; pH controllers; non-indicating temperature and pressure controllers.

In Attendance: L. M. Morley, V. P.; & Gen. Sales Mgr.; K. R. Knoblauch, Asst. Gen. Sales Mgr.; W. H. Steinkamp, Asst. Gen. Sales Mgr.; O. B. Pyle, Phila. Industrial Mgr.; J. J. Horner, E. J. Klein, J. E. MacConville, L. T. MacGill, E. L. McCarthy, J. D. Root, H. D. Ruch, A. Zeller.

Brush Development Co., Cleveland, Ohio 505

Exhibiting: Contour analyzer; direct inking oscillograph; stress-strain analyzer; six-channel oscillograph.

In Attendance: Hoyt Stearns, Mgr. Instrument Div.; E. M. Hensley.

Buffalo Meter Co., Buffalo, N.Y. ..215

Exhibiting: "Niagara" and "American" liquid meters, volumetric type for all non-corrosive liquids.

In Attendance: H. F. Barrett, Sales Mgr.

Builders Providence, Inc., Providence R. I. 543

Exhibiting: New pneumatic meter for flow, etc. meters; "Shuntflow" and "Propel-oflo" main line water meters; "Chronoflo" meters.

In Attendance: G. W. Kelsey, V. P. & Gen. Sales Mgr.; W. W. Adams, Mgr., Engineered Products Sales; A. A. Wood, W. S. Codell, Philadelphia Reps.

Burgess Battery Co., Freeport, Ill. 229

Exhibiting: Dry batteries and A. M. power units, complete line and design for special applications.

In Attendance: L. D. Foust, Sales Engr.; J. B. Mullen, Engr.

Burling Instrument Co., Newark, N. J. 550

Exhibiting: Temperature controls for laboratories, industrial processes, furnaces and ovens (—100° to 1400°F); standard tubes or special alloys and ranges of tubing.

In Attendance: H. S. Burling, President.

Century Geophysical Corp., Tulsa, Okla. 133

Exhibiting: New tubular multiple-element galvanometers; oscillographs, audio amplifiers for geophysical and allied use. Oscillographs. Geophysical prospecting for oil, ore, etc.

In Attendance: M. E. Morrow, Ex. V. P.; J. A. Stafford, Dev. Engr.

Clapp Instrument Co., Webster Mass. 542

Exhibiting: New "Acrafloat" liquid level switches. Pressure gages; "Acraflow" to indicate metered flow and to operate signaling devices or relays.

In Attendance: Charles W. Clifft. Pres. & Gen. Mgr.; Theodore W. Lanman, Treas. & Sales Mgr.; O. J. Hardegen, Production Control; B. E. Pratt, Plant Supt.; John Whiddett, Phila. Rep.

C. P. Clare & Co., Chicago, Ill. 102

Exhibiting: New hermetically-sealed relays; spring-driven stepping switches; small telephone-type relays; dustproof plug-in type relays. Relays; lever keys; turn keys.

In Attendance: D. R. Dooley, V. P.

Climax Engrg. Co., Controls Div., Tulsa, Okla. 302

Exhibiting: New diaphragm control valve seiries for 10,000# working pressures in coal hydrogenation. Control valves; liquid level controls, time cycle controls; Mercoid switches. Valve consulting service.

In Attendance: Jimmy Dvoracek, Sales Mgr.; A. J. Hanssen, Ch. Engr.; P. E. Bowles, Salesman; Ross B. Baze, Dist. Mgr.

Cole Instrument Co., Los Angeles, Calif.....532

Exhibiting: Panel instruments; aircraft instruments; switchboard instruments; aircraft electrical system testers; insulation testers; megohmeters; industrial analyzers; portable instruments; phase sequence indicators; galvonometers; pyrometers; special switches; thermocouples; transformers; switchboard shunts. Designers and engineers of special electric and electronic equipment.

In Attendance: F. H. Cole, Owner; A. W. Smith, Sales Mgr.

Conoflow Corp., Philadelphia, Pa...249

Exhibiting: New springless Conomoter in operation; air reducing regulator and filter combination for instrument air supply service. Full line of regulators.

In Attendance: R. B. Werey, Pres.; M. M. Watkins, V. P. and Sec'y; John C. Koch, Sales Mgr.; J. R. Simpson III.

Consolidated Engrg. Corp., Pasadena, Calif. 226

Exhibiting: New "System D" 3-kc, static-dynamic recording equipment. Leak detector; vibration meter; vibration pick-ups; accelerometers; torsiographs; mass spectrometers.

In Attendance: Robert L. Smallman, Dir. Sales; George H. West, Mgr., Adv. and Sales Promotion; H. W. Ruby, Eng. Recording; Rex Welch, Eng., Leak Detector; A. P. Gifford, Engr., Mass Spectrometer.

Continental Equipment Corp., Coraopolis, Pa. 217

Exhibiting: Butterfly valves.

In Attendance: J. D. Hantz, A. M. Capper, W. F. Hartmann, C. A. Daily III.

Cook Electric Co., Greenwich, Conn. 241

Exhibiting: Relays; pressure switches; bellows devices; expansion joints; stratopaxing. Development of electronic devices.

In Attendance: Robert F. Stockton, Southeastern Div. Mgr.; M. S. Jacobs, Walter Gieryk, M. S. Jacobs & Assoc., Pittsburgh, Pa.; W. A. Brown, W. A. Brown & Associates, Arlington, Va.

Cramer Company, Inc., Centerbrook, Conn. 403

Exhibiting: New high-torque synchronous instrument motor; synchronous chart drives; cycle timers; interval timers; running time meters; pulse timers; percentage timers; time delay relays; impulse timers; duplex cycle timers; multi-contact timers. Automatic reset timers; Sauter astronomic time switches; special timing devices.

In Attendance: R. W. Cramer, Pres.; F. R. Brophy, V. P.; A. DeCew, Sales Mgr.; John C. Whiddett, C. E. Nelson, W. D. Miller, Philadelphia Sales Reps.

Davis Emergency Equipment Co., Newark, N. J.....304

Exhibiting: New continuous combustible gas analyzer and controller; precision thermal conductivity gas purity recorder. Gas analysis instruments by the electrical conductance methods, by the catalytic combustion method, by the thermal conductivity method. Engineering for specific field problems.

In Attendance: F. R. Davis, Pres.; F. Taylor, Jr., Gen. Mgr., Inst. Div.; F. J. Schirm, Ch. Engr.; J. F. Coonan, Sales Engr.

Davison Chemical Corp., Baltimore, Maryland 441

Exhibiting: New silica gel instrument air dehydrators. Engineering study of design and construction for applications.

In Attendance: Richard S. Van Note; G. Page West, Jr., Kenneth Smith, Robert Goll.

Dehydraire Div., Davis Engineering Corp., New York, N. Y.....247

Exhibiting: New internal electric activation instrument air dryer using air from system instead of separate blower for activitation air. Cabinet model "Dehydraire."

In Attendance: C. A. Chamberlain, V. P.; E. W. Anders, V. P.; J. B. Henderson and M. F. Savoy, Engrs.

Distillation Products, Inc., Rochester, N. Y.....527

Exhibiting: New ionization gage for high multiple locations; electronic temperature vacuum measurement. High vacuum gages, pumps, valves, and systems such as vacuum furnaces, stills and coaters. High vacuum engineering and construction; scientific glass apparatus fabrication.

In Attendance: W. F. Dolhe, A. H. Hartman, C. W. Hermann, Sales Engrs.

Eagle Signal Corporation, Moline, Ill. 530

Exhibiting: Timers, reset and program types with single and multiple circuits; electric counters; processing timer controls engineered for specific applications.

In Attendance: W. F. Keegan, C. H. Comisky, Sales Reps.

Thomas A. Edison Co., Inc., West Orange, N. J.....517

Exhibiting: New temperature monitor for multiple locations; electronic temperature controller. Electrical resistance type thermometer bulbs; sealed thermal relays.

In Attendance: H. K. Mann, Sales Engr.; F. W. Watson, Ind. Sales.

Electric Tachometer Co., Philadelphia, Pa. 240

Exhibiting: New small electric tachometer for continuous operation; speed and production recorder for installation at machine or remote location. Instruments for indicating, counting and recording speed for industrial, laboratory and marine service

In Attendance: M. F. Porter, C. H. Clapham, S. Hamilton, R. A. Clayton, T. J. Porter.

Electro-Tech Equipment Co., New York, N. Y.....114, 116

Exhibiting: New electrical instruments and control equipment; pyrometric temperature controllers and pyrometers.

In Attendance: S. J. Koch, A. Prince.

Energy Control Co., Philadelphia, Pa...438, 440, 442, 443, 444, 445, 446, 447, 448, 449

In Attendance: W. G. Gallagher, W. E. Williams, W. A. Gregory, A. A. Harrison, J. J. Kelly, R. R. Bitterlich, W. C. Ruglass, E. L. Freemire, Robert Trenner.

Englehard, Inc., Newark, N. J....308

Exhibiting: New furnace atmosphere indicator differentiating between oxidizing and reducing. CO_2 analyzers; thermocouples; controllers.

In Attendance: C. K. Krause, Gen. Mgr.; E. P. Anderson, Development Engr.; J. H. Oetjen, Rudolph Freund, Sales Engrs.; Arnold Brenton, Engr.

Equipoise Controls, Inc., Mt. Vernon, N. Y.....520

Exhibiting: New pressure snubbers, porous stainless steel discs; bimetal thermometers, solid drilled stem and conn. reset; air and gas filters, porous stainless steel filter unit; hand tachometer, with magnetic drag principle with automatic temperature compensation and jewel bearings.

In Attendance: Roy F. Coleman, R. McGregor.

Esterline Angus Co., Inc., Indianapolis, Ind. 212

Exhibiting: Recording instruments, tachometer generators and portable current transformers.

In Attendance: D. J. Angus, Pres., R. J. Kryter, Sales Mgr.; Linn and Robert Morrow, Sales Reps.; Lewis Meier, Jr., Sales Engr.

Fischer & Porter Co., Hatboro, Pa. 500, 502, 504

Exhibiting: New continuous recording viscosimeter; recording-controlling "Ratiotronic" for flows as low as 1 cc/min; pneumatic ratio controller; "Flowrator" for variable area flow rate.

In Attendance: Wm. A. Diament, Sales Mgr.; John O. Larson, Robert Johnson, P. T. Charest, Marvin Care, Div. Mgrs.; Edw. Muhleisen, George Gard, Lee Benson, Field Engrs.

Fisher Governor Co., Marshalltown, Iowa.....219, 221

Exhibiting: New pilot pressure loaded gas pressure regulator; valve positioner; dual-relay-operated displacement type liquid level controller, "Wizard" pilot; "Wizard" pilot-operated pressure regulator; direct and reverse acting DMV's; liquid level controllers; manual operator swee-flow type DMV; 3000# and 6000# cast steel sectional valve bodies; snap acting "Wizard" and relays or pilots; complete line top and bottom guided V-port throttle plug and ratio plug inner valves; "Micro-Flute" and "Micro-Form" PUP type inner valves.

In Attendance: J. W. Fisher, Exec. V. P.; P. A. Elfers, V. P. and Sales Mgr.; R. A. Engel, V. P. Engineering; L. E. Eige, Asst. Sales Engr.; T. B. Burris, Asst. Sales Mgr.; G. F. Brockett, Ch. Engr.; A. E. Ehrke, Hugh D. Hale, Frank D. Watson, C. B. Petty —Sales Engineers.

Flowmeter Corp. of America, High Falls, N. Y.....104

Exhibiting: New "Stroboflow" stroboscopic indication flow meter; "Motorspeed" thyratron armature current motor speed controller; vacuum operated electronic relay. Industrial research service

In Attendance: Berthold A. Knauth, Pres. and Engineers.

Foster Engrg. Co., Newark, N. J. .442

Exhibiting: Control valves.

In Attendance: H. J. Fortier, Sales Mgr.; Energy Control Corp., Philadelphia Representatives.

Foxboro Company, Foxboro, Mass.....535, 537, 539

Exhibiting: New multiple point recorder using "Dynalog" all-electronic principles; auto-selector controller where one operator is positioned from either of two related variable dew point recorder for continuous direct measurement of humidity; improved differential pressure recorder; d/p cell (differential pressure) transmitter; resistance bulb; model 40 controller; EMF dynalog instruments—recorder, indicator, recording controller. (Will exhibit only new products.)

In Attendance: C. E. Sullivan, V. P.; and Gen. Sales Mgr.; V. V. Tivy, Sales Mgr. Refining; D. H. Fuller, Sales Mgr., Electronics; J. J. Burnett, Mgr., Central Sales Div., Chicago; C. C. Fuller, Mgr., Eastern Sales Div., N. Y.; A. H. Shafer, District Mgr., Pittsburgh; H. L. Lee, District Mgr., Cleveland.

Fredericks Company, Bethayres, Pa.....536, 538

Exhibiting: New "Televac" high vacuum indicating, recording and control equipment; special scientific glassware; Pyrex Dewar breakers. Vacuum gages; special metal-to-glass seals. High-vacuum engineering and glass technology.

In Attendance: J. Gordon Seiter, Sales; Charles R. Skelton, Sales; Wm. Johnson, Jr., Engineering.

Fulton Sylphon Div., Robertshaw Fulton Controls Co., Knoxville, Tenn.....211, 213

Exhibiting: Temperature controls; packless valves; bellow assemblies.

In Attendance: F. G. Gross, V. P.; L. S. Dysert, Engr.; E. D. Rogers, Adv. Mgr.

General Electric Company, Schenectady, N. Y.....231, 233, 235

Exhibiting: New "I-50" watthour meter; new mass spectrometer; leak detector; dew point recorder; strain gage; metals comparator. Selection of G-E meters and instruments.

In Attendance: Exhibit Staff—Ira S. Meckly, Charles M. Slocum, Special Products—R. R. Person, Sales Mgr.; W. E. Herrimann, Sales Engr.; N. Gildersleeve, G. A. Dotey, C. P. Swan, R. A. Sandholm, C. Briggs, J. M. Popps, A. N. Moore. *Meter and Instruments Div.*—J. M. Whittenton, Sales Mgr.; E. G. W. Lagier, J. C. Kondike, Jr., N. S. Stone, H. S. Day.

Gotham Instrument Company, New York, N. Y.....128, 130

Exhibiting: New moisture meter; program controllers; process time controllers. Temperature and pressure indicating, recording and controlling instruments.

In Attendance: Walter Halpern, Pres., J. P. Henderson, Ch. Engr.; R. Hamerschlag, Sales Mgr.; John C. Whiddett Co., Reps.

Gow-Mac Instrument Co., Newark, N. J.....507

Exhibiting: Thermal conductivity gas analyzers and gas analysis cells.

In Attendance: James L. McFadden, President; Wm. G. Gow, Vice President; James A. McFadden, Sales Dept.

Hagan Corporation, Pittsburgh, Pa.....228, 230

Exhibiting: Ring Balance recording and integrating fluid-meter receiver; Hagan variable ratio totalizing relay; micro transmitter; micro positioner; fluid meters; automatic combustion controls.

In Attendance: Otto B. Zetter, Ch. Engr., Ring Balance Div.; R. R. Donaldson, Dir. of Engr., Hagan Corporation.

Hammel Dahl Co., Providence, R. I.....431, 433

Exhibiting: New; complete set—1", 1½", 2", 3", 4" 1500-lb. ASA "Venturiflo" angle valves, "Microflo" control valve with 3000# stainless steel body, solid Stellite spline plug, diaphragm control valve with cast iron body; diaphragm control valve equipped with continuously connected handwheel; supersensitive gas regulator; "Type 3644-BSZ" diaphragm control valve, stainless steel body with 300#ASA standard flanged ends; "Venturiflo" angle valve with 600# cast steel ASA flanged body with Venturi throat.

In Attendance: E. T. Dahl, Pres.; B. A. Irwin, V. P.; Otto Kneisel, Asst. Ch. Engr.; J. H. Curran, Design Engr.; David Golner, Sales Engr.; Thomas Ponton, V. P.; Joe Navas, P. A.; Harold Miller, John E. Charsha, Jr., Sales Engrs.

Hathaway Instrument Co., Denver 10, Colorado 510

Exhibiting: High-speed recording equipment—oscillographs, galvanometers; strain-gage control equipment; pressure gages; various pick-ups.

In Attendance: C. M. Hathaway, Pres. & Gen. Mgr.; W. H. Eichelberger, Ass't Chief Engr.; F. A. Newell, Sales.

Hays Corporation, Michigan City, Ind.....447, 449

Exhibiting: New electronic recording instrument for oxygen, carbon dioxide, temperature and pressure; force gage for remote measurement of pressure and fluid by means of strain. Electrical automatic combustion control; water operated CO_2 recorder; combustion meter; flow meters; remote-indicating flowmeters; multiple combustion testing instrument; portable draft gages.

In Attendance: P. T. Sprague, Pres. and G. M.; S. M. Rudolph, V. P. Sales; W. H. Pugsley, V. P. Field Research; F. I. Lackens, Adv. Mgr.; Robert Richardson, William McCown, Electronic Engineers; Don Burns, Electrical Engr.

Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport, Conn. 448

Exhibiting: New chemical gage; new low-pressure gage. Pressure gages.

In Attendance: J. V. Tracy, Sales Mgr.

Helipot Corp., So. Pasadena, Calif. 135

Exhibiting: New "Duodials," multi-turn knob dial combination for use with helical potentiometers, variable inductors, capacitors, fluid valves, etc. "Helipot" potentiometers.

In Attendance: D. C. Duncan, Sales Mgr.; C. E. Johnson, Engr.; J. C. Mugglewath, B. B. Taylor, Sales Reps.

H. O. Trerice Co., Detroit, Mich....405

Exhibiting: New 4½" dial thermometer; 4½" × 6" pressure gage. Industrial indicating and recording thermometers; temperature and pressure regulators; gauges; steam traps; air filters; air guns.

In Attendance: J. L. Brackett, F. Z. Dahn, Robert Arnold.

Illinois Testing Labs., Inc., Chicago, Ill. 202

Exhibiting: Pyrometers; "Velometers"; dew point indicators.

In Attendance: W. J. Bailey, G. F. Bertrand, J. A. Fizzell, R. C. Chelius, J. A. Ariano.

Industrial Instruments, Inc., Jersey City, N. J.....421

Exhibiting: New "Auto-Bridge" automatic sorting machine for resistance, capacitance and inductance; electrolytic conductivity recorder with automatic temperature compensation; electrolytic conductivity bridges and conductivity cells; battery-operated conductivity bridge, "Solu-bridge"; Wheatstone bridges; resistance decades; capacity decades; voltage breakdown testers; complete panel assemblies; special apparatus.

In Attendance: Philip M. Gotthold, Pres.; Dr. R. Rosenthal, Ch. Chemist.

Instruments Publishing Co., Pittsburgh, Pa. 147

Exhibiting: Instruments, The Magazine of Measurement and Control; *The Instrument Maker*, the Trade Journal of the Instrument Industry; "Elementary Engineering Electronics" by Andrew Kramer; "Mechanical Measurements by Electrical Methods" by H. C. Roberts.

In Attendance: Richard Rimbach, Publisher; M. F. Behar, Editor; C. F. Goldcamp, Sales Mgr.; Stuart Rogers, New York Mgr.; Richard Rimbach, Jr., Asst. New York Mgr.; Harold Haskett, Chicago Mgr.; James Condon, New England Mgr.; James Wright, St. Louis Mgr.; M. D. Pugh, West Coast Mgr.

Instrument Society of America ....Exhibit Hall Lobby

Exhibiting: Publications of the Society; membership information and data on the I.S.A.

In Attendance: Committee members, I.S.A.

International Nickel Co., New York, N. Y.....131

Exhibiting: Nickel and nickel alloys; voluminous engineering literature. Consulting services.

J-B-T Instruments, Inc., New Haven, Conn.....204

Exhibiting: New appliance temperature tester to measure four cold zones, two heat zones, 0-60 AC amps, 0-300 AC volts; iron temperature tester; hearing aid pocket battery tester. Vibrating reed frequency meters; rotary selector switches; temperature measuring instruments. Triplett Eastern Service Div.

In Attendance: Roland M. Bixler, Gen. Mgr.; Phillip Stevens, Sales Mgr.

Jerguson Gage & Valve Co., Somerville, Mass. 443

Exhibiting: New "Trulevel" gage for distant reading of boiler water levels; gage for suppressed scale, reduced scale or inch-per-inch distant reading of water levels; transparent gage for 20,000# test pressure. Reflex and transparent gages and gage valves.

In Attendance: James A. Ford, Sales Mgr., Energy Control Co., Phila. Rept.; E. E. VanHam, V. P.

Kelly-Koett Mfg. Co., Covington, Ky. 534

Exhibiting: New survey meter for detection of beta, gamma and x radiation; beta scaler, scale of 64, scale of 256; alpha scaler, scale of 64; gamma pocket chamber; slow neutron pocket chamber, charge reader; high range dosimeter; dosimeter; charging unit for dosimeter. Consultation for radiation detection instrumentation.

In Attendance: A. H. Feibel, Pres.; L. E. Rasmussen, Gen. Mgr. Inst. Div.; S. M. Rudder, Jr., Head Sales Inst. Div.; P. M. Schmitz, Regional Mgr.; E. P. Cohn, Sales Engr.; H. R. Levinger, Mgr., Supply & Accessory Div.

Kieley & Mueller, Inc., North Bergen, N. J. 519, 521

Exhibiting: Diaphragm-motor valves, pressure regulators for process, power and oil industries.

In Attendance: Joseph O'Connor, Ward K. Stallings, R. J. Donnelly, C. D. Close, P. H. Putnam, E. C. Zwicker, C. Gregory.

Cuno Engineering Corp., Meriden, Conn. 209

Exhibiting: Filters and Strainers.

In Attendance: Sheffler Gross Co., Phila. Reps.

Lawter Chemicals Co., Chicago, Ill.430

Exhibiting: New high-response fluorescent paints for use on black-lighted instrument dials and pointers. Daylight fluorescent paints for use on conventionally lighted dials for extra visibility of calibration pointers. Luminescent paints; printing ink vehicles; hot melt adhesives. Consultation service.

In Attendance: Daniel J. Terra, Pres.; Henry D. Ferguson, V. P.; John A. Harmon, Wendell W. Clifford, Sales Engrs.

Leeds & Northrup Co., Philadelphia, Pa.....246, 248

Exhibiting: New 140-point "Speedomax" recorder for temperatures of bearings, boiler and superheater tubes, etc.; "Speedomax" microvolt recorder, "Micromax" oxygen recorder method using thermal conductivity principle; pneumatic control using strip chart controller. High-speed automatic indicator for over 100 thermocouple temperatures; multiple-point recorder; non-indicating temperature controller; glass-electrode pH indicator; optical pyrometer; portable millivolt and temperature indicators for checking pyrometers; thermocouples; resistance thermometer elements; radiation detector; gas-analysis cell; electrolytic conductivity cell.

In Attendance: L. E. Emerich, Mgr. Tech. Sales Div.; A. E. Tarr, Mgr., Ind.

Sales Div.; B. F. Keene, Phila., Ind. Sales Mgr.; R. K. Davis, M. B. Barba, P. V. Newman, M. B. Brown, C. H. Parker, E. C. Wood, H. L. Pfaffhausen, B. Jay, J. C. Emerline, Field Engr.; K. W. Maeblus, Service Engr.; E. R. Fiske, Jr., Advertising Div.

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Leslie Co., Lyndhurst, N. J....127, 129

Exhibiting: New "Class T" temperature regulator suitable for steam or liquid, convertible from heating to cooling service in the field. Reducing valves; pump governors; temperature and pressure controllers and strainers.

In Attendance: R. W. Boettiger, Sales Mgr.; J. M. Wylie, Sales Engr.; E. J. Kilgore, E. Elliott, H. G. Jones, Sales Reps.

Linde Air Products Co., New York, N. Y.....526

Exhibiting: New synthetic sapphire balls polished to 1 microinch of perfect sphericity; centerless-ground whole synthetic sapphire boules and rods. Synthetic sapphire blocks, plates, combustion ports, orifices; synthetic ruby and spinel; fine alumina (abrasive). Consultation on wear, superpolishing, application of synthetic crystals.

In Attendance: A. K. Seeman, Mgr., Synthetic Crystal Div.; J. J. Hock, Synthetic Crystal Promotion; I. Brown, Jr., Corundum Sales.

Liquidometer Co., Long Island City, N. Y. 207

Exhibiting: New "Scaleometer" remote-indicating tank content gage; milk gage; "Columgage" hydrostatic liquid level gage. Direct-reading "Liquidometer"; "Senior Liquidometer"; electric "Liquidometer"; "Levelometer"; direct-reading milk gage.

In Attendance: J. J. Cosgrove, H. T. Cullinan, A. Wickesser, W. C. Armstrong.

J. E. Lonergan Co., Philadelphia, Pa. 143

Exhibiting: New "Type FSS" all-stainless-steel relief valves; "Type LH" high-pressure indicating gage to 0-100,000 psi; "Pressure-link" bellows-actuated low-pressure gage. Ported disk nozzle type safety and relief valves; various conventional and special-purpose relief valves; pressure indicating gages, Bourdon tube, bellows and diaphragm actuated; air and steam whistles; water level gages.

In Attendance: A. L. Diederich, Jr., Sales Mgr.; F. M. De Pass, Asst. Sales Mgr.; H. J. Hartley, R. V. Smith, Design Engineers; A. W. Lenderoth, Special Representative.

Macbeth Corp., New York, N. Y...309

Exhibiting: New Titrimeter-pH meter. Laboratory and industrial pH meters.

In Attendance: F. G. Paully, Norman Macbeth.

Magnetrol, Inc., Chicago, Ill.....445

Exhibiting: New small flow switches with solder-end bodies for sweat-fitting attachment; manometer type high-pressure liquid-level switches; small switch mechanism. Flow and float switches.

In Attendance: E. J. Snetsinger, Sales Mgr.; B. L. Binford, Ch. Engr.

Manning, Maxwell & Moore, Inc., Bridgeport, Conn.....103, 105

Exhibiting: New pneumatic receiver gage for pressure transmission systems; dial thermometer with 180° turn mounting stem; extruded case industrial thermometer; "Microsen" d-c. amplifier. Dead-weight gage tester; "Duragage" indicating and recording gages.

In Attendance: E. F. Nordstrom, Mgr. Instrument Sales, E. M. Dederer, Mgr. Gauge Sales; L. E. Gebhardt, R. D. Mariner, W. F. Loos, R. Beck, N. Belaef, C. N. Sugden.

Mason-Neilan Reg. Co., Boston, Mass.....242, 244

Exhibiting: New valve positioner with integral by-pass; mechanical level controller with instrument pilot; displacement type level controller with reset and remote transmission. Diaphragm control valves; liquid level controllers; pressure regulators; industrial instruments for temperature, pressure and flow.

In Attendance: F. K. Morrison, V. P.; Ralph A. Rockwell, Dir. Engrg.; Paul Wing, Jr.; Clarence W. Wood, Lawrence Hawes, A. Blair Powell, Carl W. Gram, Warren F. Priest, Eric A. Bianchi, Graham Davis.

McGraw Hill Publishing Co., New York, N. Y.....117

Exhibiting: "Electronics," a publication.

In Attendance: W. W. MacDonald, Managing Editor; Wallace B. Blood, Mgr.; Warren Sheer, Representative.

Meriam Instrument Co., Cleveland, Ohio.....314, 316

Exhibiting: New manometer check valve for universal application; portable manometers for checking meter differentials in the fields. U and well type manometers; draft gages; tank liquid level gages; indicating flowmeters and accessories, equipment for measurement of pressures, vacuum and differentials and as applied for flow metering.

In Attendance: J. B. Meriam, Jr., Pres.; Mark Meriam, Secretary; A. A. Hejduk, V. P.; E. Brosius, D. R. Pressey, Phila. Reps.

Milton Roy Co., Philadelphia, Pa...112

Exhibiting: New concentration control system by continuous titration; control of concentrations where direct readings on pH value, oxidation potential, etc. are on flat portion of curve. Controlled-volume pumps with electronic control

In Attendance: R. T. Sheen, Pres.; M. S. Maleson, Dist. Rep.; Paul C. Flucke, Chem. Engr.

Mine Safety Appliances Co., Pittsburgh, Pa.....119, 121

Exhibiting: New colorimetric CO tester indicates presence of CO in air from 0.001% to 0.1% by volume; portable methane alarm. Combustible gas indicator; benzol indicator; hydrogen sulphide detector; explosimeter; methane detector; oxygen indicator; midget impinger and microprojector.

In Attendance: N. W. Hartz, Ind. Sales Dept.; E. C. Brainerd, J. P. Sherwin, J. G. Gaskill, Sales Reps.

Miniature Precision Bearings, Inc., Keene, N. H.....101

Exhibiting: New miniature ball bearings. Precision ball bearings for instruments; special ball bearings.

In Attendance: H. D. Gilbert, Pres.; W. S. Pierce, Jr., V. P. and Ch. Engr.; John S. Lawton, V. P.; W. L. Timmerman, Asst. to V. P.

Moore Products Co., Philadelphia, Pa.....106, 108, 110

Exhibiting: New "Nullmatic" controllers demonstrated on temperature and flow applications. Instruments for measurement and control of flow, temperature, pressure, liquid levels.

In Attendance: Chas. H. Thompson, Sales Mgr.; J. E. Gambrill, Detroit Branch Mgr.; J. J. Fregeau, Chicago Branch Mgr.; R. A. Barnes, Houston Branch Mgr.; H. S. Garrett, Application Engr.; Dean Valentine, Ralph H. Owens, Sales Engineers.

Nash Engineering Corp., So. Norwalk, Conn. 140

Exhibiting: "Clean Air" compressor for instrument air supply. Pump and filter in operation.

In Attendance: F. W. Green, Mgr. Industrial Sales; J. B. Wright, Mgr. Building Equipment Sales.

National Bureau of Standards, Washington, D. C.....5, 548

Exhibiting: New magnetic fluid flutch; variable-stiffness spring transducer.

In Attendance: Daniel S. Goalwin, Physicist; Henry D. Saunderson, Mech. Engr.; L. Bragaw, Technical Reports.

National Technical Labs., Pasadena, Calif.....405, 408

Exhibiting: New Beckman glass prism spectrophotometer; a-c operated pH meter; radiation meters; Beckman "UltrOHmeter"; glass electrodes. Beckman instruments.

In Attendance: A. O. Beckman, Pres.; T. F. Herring, V. P.; E. C. Bowen, E. D. Haller, G. R. Kincaid.

Naval Ordnance Lab., Naval Gun Factory, Washington, D. C. 245

Exhibiting: New interferometer optical instrument for detecting flaws in glass; LF acoustic system to detect pressures from zero to 200 CPS; relay tester measures operating sensitivity and operating time of contacts; air test pot for testing air leakage of gaskets, porosity of metals; etc.; test chassis for expediting test set-ups.

In Attendance: Naval Ordnance Laboratory physicists and engrs.

New Hampshire Ball Bearings, Inc., Peterborough, N.H. 544

Exhibiting: New conventional (Conrad) radial ball bearing—smallest in U. S., 5/64" bore × 1/4" O.D. × 3/32" wide, fully ground. Micro ball bearings.

In Attendance: A. N. Daniels, Design Engr.; R. H. Cherwin, Field Engr.

New York Naval Shipyard, Naval Base Station, Brooklyn, N. Y....139

Exhibiting: Zero Resistance photometer; instrument fuse analyzer; concentricity-parallelism gage; time cycling clock; open-circuit indicator; calibration apparatus for three-phase power-factor meters; load life test equipment for power-type wire-wound rheostats; general views of Material Laboratory.

In Attendance: J. T. Cataldo, Electrical Engineer.

Optical Film Engrg. Co., Philadelphia, Pa.....511

Exhibiting: Front-surface mirrors; beam splitters; crystal coatings; high-vacuum evaporators; low-reflection coatings.

In Attendance: Richard Denton.

Palmer Thermometers, Inc., Cincinnati, Ohio 444, 446

Exhibiting: Industrial, laboratory, dial and recording thermometers.

In Attendance: Bartlett Palmer, Pres.; Curtis Mitchell, V. P.; Frank W. Probst, Plant Mgr.; Douglass Hitt, Sales and Order Dept.

Penn Industrial Instrument Corp., Philadelphia, Pa.....438, 440

Exhibiting: New multi-pen 12" chart temperature and pressure recorders; temperature and pressure recorder-controllers, on-off type and 10% throttling range type; pneumatic flow transmitter with square-root rectification. Hays-Cochrane flow meters.

In Attendance: W. C. Bennett, Pres. and Gen. Mgr.; Wm. Melas, V. P. and Ch. Engr.; Adalbert Melas; C. F. Warr, Jr.; D. J. Kamalo; F. P. A. Wagner; W. L. Applegate.

Perkin-Elmer Corp., Glenbrook, Conn. 132

Exhibiting: New Tiselius electrophoresis apparatus for determination of identity, concentration and purity of solutes. Recording infrared spectrometer; flame photometer; breaker type d-c. amplifier.

In Attendance: Dr. Van Zandt Williams, Dir. Inst. Dev. & Sales; Paul A. Wilks, Wm. Hargrave, Sales.

Permo, Inc., Chicago, Ill.....307

Exhibiting: Instrument and fine mechanism pivots.

In Attendance: George M. Mencke, Ch. Engr.; I. W. Duffy, Mgr., Pivot Dept.

The Permutit Co., New York, N. Y. 547

Exhibiting: Portable CO_2 meter; specific gravity meter; exhaust gas analyzer, furnace atmosphere analyzer; gas analysis instruments for special service.

Philadelphia Thermometer Co., Philadelphia, Pa. 243

Exhibiting: New Roto-stat regulator: Micro-set regulator maximum and minimum thermometer, no magnet required; automatic temperature controlled stainless-steel hot chocolate dispensing urn. Industrial thermometers; laboratory thermometers; thermostats; regulators, relays

In Attendance: Edward Collins, 3rd.; Thos. J. McCann.

Photoswitch, Inc., Cambridge, Mass.227

Exhibiting: New Type 30HL1 electronic timer; Type 10CB1 electric level control; photoelectric counter set; five new "Fireeye" combustion control systems. Photoelectric and electronic controls.

In Attendance: John A. Long, V. P.; L. D. Sibley, Ind. Sales Mgr.; John C. Whiddett, Charles E. Nelson of John C. Whiddett Co., Philadelphia Reps.

Physicists Research Co., Ann Arbor, Mich.....113, 115

Exhibiting: New "Profilometer" for production measurement of surface roughness; "Proficorder" for recording surface profiles of waviness and roughness; "Anderometer" for production testing of ball bearings; "Wavometer" for production testing of waviness in grinding of bearing races, etc.

In Attendance: Ernest Abbott, Mgr.; Frank Kabat, Fred J. Engelke, Field Reps.

Precision Thermometer & Instrument Co., Philadelphia, Pa.303

Exhibiting: New improved "Densitrol." Dial thermometers; "Photo-Tem."; laboratory and industrial thermometers, mercurial barometers, vacuum gages.

In Attendance: W. D. Laverell, V. P. and Sales Mgr.; J. Boonshaft, Design Engr.; C. H. Waser, Pres.

Precision Tube Co., Philadelphia, Pa. 407

Exhibiting: New "Trumphet" brass and phosphor-bronze Bourdon tubing shaped for sensitive pressure and vacuum gages; precision "Coaxitube" insulated wire in seamless metal shield. Seamless tubing of copper, brass, aluminum, nickel non-ferrous alloys. Engineering service and metallurgical recommendations.

In Attendance: H. Jack, Jr., Secy.-Treas.; Charles T. Flachbarth, Ch. Engr.; Chester S. Pondo, Metallurgist; Albert J. Armstrong, Prod. Mgr.

Production Instrument Co., Chicago, Ill. 310

Exhibiting: New mechanical and electrical counting devices; automatic batch counters; centralized production counting; actuating switches; electric-eye counting.

In Attendance: Jos. F. Visin, V. P. & Sales Mgr.; R. W. Lawson, Sales Rep.

Proportioneers, Inc., Providence, R. I.....541

Exhibiting: New loss-in-weight proportioning scale with pneumatic controller; differential control applied to multiple proportioning. "Adjust-O-feeder"; "Treet-O-Control"; "Vol-U-meter"; loss-in-weight blender. Engineering of proportioning problems.

In Attendance: R. P. Lowe, Pres.; P. V. Crowther, Ind. Engr.; A. A. Wood, B. H. Mayer, Phila. Reps.

R.C.A. Victor, Camden, N. J...531, 533

Exhibiting: New electron microscope; industrial type oscilloscopes; industrial type electronic measuring instruments.

In Attendance: M. C. Banca, S. M. Electron Microscope; L. E. Goodwin, S. M. Test and Meas. Equip.; H. Pastoriza, R. J. Miller, P. A. Greenmeyer, Sales Engrs. Electron Microscope; A. Liebscher, L. L. Salton, G. W. Kimball, Sales Engrs. Test & Meas. Equip.; T. E. Flynn, Adv. Sec.; R. W. Robins, H. W. Berry, M. J. Ackerman, R. A. McDermody, P. C. Smith, R. Picard, J. Reisner, S. M. Zoeller.

Republic Flow Meters Co., Chicago, Ill.....413, 415

Exhibiting: New pneumatic flow transmitter with output pressure linear with flow and square-root extraction in operation. Pneumatic differential pressure transmitter in operation. Combustion control panel including boiler meter, draft and pressure gages, automatic control equipment; high-pressure steam reducing valve.

In Attendance: J. B. McMahon, Mgr. Sales Promotion; H. R. Kessler, Mgr. N. Y.; L. C. Walter, Mgr. Phila.; R. B. Drescher, Mgr. Pittsburgh; T. E. Bell, Mgr. Atlanta; F. E. Segermark, S. A. Anderson, U. A. Rothermel, Sales Engrs.

Roller Smith Div., Realty & Industrial Corp., Bethlehem, Pa.515

Exhibiting: New portable volt-ohm-milliammeter; appliance tester; watthour meter; meters for Geiger counter application. Electrical indicating instruments; precision balances; rotary switches and relays.

In Attendance: E. S. Maury, Mgr. Sales.

Rowe Engineering Corp., Chicago, Ill.....320, 321

Exhibiting: IPS 50000-50 KV Iso volt dc power supply; SBG 41 Synchronizing and blanking generator RDA 33 Radial deflection amplifier; VA 25 Video amplifier (30 cycles to 25 megacycles); synchro cyclic timers; oscillograph accessory apparatus; millisecond measurement equipment; consulting engineering—designing of custom built precision apparatus.

In Attendance: H. C. Rowe, Pres.; H. H. Bingham, Sales Dept.; D. V. Sinninger, Ch. Engr.; J. F. Brumbach, Engr. Dept.

R-S Products Corp., Philadelphia, Pa.....315, 317

Exhibiting: New "Leveltronic" level control; duplex strainer for clean water for industrial processing and utility purposes. Controls and shut-off valves. Consultation on control and shut-off of liquids, gases or solids.

In Attendance: D. W. Hopkins, Ex. V.P.; R. C. Ayers, Sales Mgr., Valve Div.; Donald C. Culver, Ch. Engr., Electronic Div.

Rubicon Co., Philadelphia, Pa.....528

Exhibiting: New recording automatic hydrogen sulphide analyzer (approx. 0.5 to 500 PPM); recording nitric oxide analyzer (0.5 to 50 PPM); photoelectric galvanometer; temperature-calibrated potentiometer. Resistance thermometer bridge; high-precision potentiometer; portable precision potentiometers; standard resistors; decade resistance boxes; Wheatstone and Kelvin bridges, spotlight galvanometer; photoelectric colorimeter for chemical analysis; general-purpose photometer.

In Attendance: W. H. Schaeffer, Sales Mgr.; P. M. Andress, Sales Engr.; George Allsop, Jos. Walls, Engr.

Sanborn Company, 39 Sanborn St., Cambridge, Mass. 319

Exhibiting: New "Visco-Cardiette" direct-writing oscillograph with heated stylus on heat-sensitive paper, galvanometer natural frequency 45 cps., sensitivity 1 cm/mv.; "Twin-Viso" same except has two channels; electromanometer, condenser microphone in bridge circuit for measuring liquid and gas pressures. Galvanometer assemblies; photographic type oscillographs; single and multichannel electrical recording instruments.

In Attendance: A. E. Lonnberg, Sales and Service Mgr.; Dr. Arthur Miller, Ch. Elec. Engr.; Ralph E. Robertson, Phila. Sales Rep.

Schutte & Koerting Co., Philadelphia, Pa.....203, 205

Exhibiting: New ball type flow indicator; induction type rotameter transmitter to operate various makes of electric recorders. Electronic recording rotameters; electric recording rotameter; recording and alarm rotameters for minute flows; universal rotameter; high-pressure armored rotameters; by-pass rotameter; "Rotastat" flow control; rotary flow indicator; flapper and check valves flow indicator; distillate and angle type flow indicators.

In Attendance: H. W. Gripton, Engr.; R. A. Nelson, Engr.; W. H. Gerber, Elec. Engr.; A. Varga, Inst. Engr.; S. G. Ketterer, Chem. Engr.

Seely Instrument Co., Inc., Niagara Falls, N. Y.....434

Exhibiting: New "Aeromac" electric timers, also available for ganging for multiple circuits. Time cycle controllers; two, three, and four way hydraulic diaphragm operated valves; solenoid and diaphragm operated air valves.

In Attendance: A. M. Patterson, Pres.; G. C. Butler, V. P.; A. A. Hohmann, Sales Rep.; O. W. Heyman, Akron Branch Mgr.

Shallcross Mfg. Co., Collingdale, Pa. 311, 313

Exhibiting: New portable standard resistor; single high-precision resistors; whether-proof type precision resistors; subminature and minature precision resistors; high-voltage divider for DC and AC; portable self-contained Kelvin-Wheatstone bridge; portable self-contained Kelvin bridge; portable self-contained combined potentiometer and Wheatstone bridge; portable self-contained fault location and Wheatstone bridge; transmission gain test set. Measuring bridges; service instruments; resistors and attenuators. Research, designing, and development of instruments and resistance networks.

In Attendance: D. H. Shallcross, Pres.

Sharples Corp., Philadelphia, Pa...509

Exhibiting: New particle size analyzer (1 to 100 microns). Centrifugal machinery.

In Attendance: Allen S. Dunn, C. E. Printz, C. M. Ambler.

Sheffler Gross Co. Philadelphia, Pa. 207, 209, 211, 213, 215

Exhibiting: New "Micro-Klean" filters for instrument air service. Products of Fulton Sylphon Co., Buffalo Meter Co.; Liquidometer Corp.; American Car and Foundry Co., Valve Div.

In Attendance: M. Sheffler, S. Gross, T. J. Kenny, Partners; G. C. Halwas, Chas. Bieber, J. H. Wilkers, P. C. Prager, G. K. Fisher, A. T. Lawley, Field Engineers.

Simplex Valve & Meter Co., Philadelphia, Pa. 549

Exhibiting: New "Type H" meter—indicating, recording, and totalizing for use with Venturi tube, flow nozzle or orifice plate. "Type TG" Venturi tube.

In Attendance: Everett M. Jones, V. P. and Gen. Mgr.; Richard A. McQuade, Asst. to Gen. Mgr.; Frank E. Gerlitz, Jr., Sales Mgr.

Smith Meter Co., New York, N. Y.141

Exhibiting: Rotary positive displacement meters; electric remote liquid level gage; strainer; flow rate control valve and automatic meter predetermine stop device; remote electrical meter registration and ticket printing.

In Attendance: Wilson Milligan, N. Y. Div. Mgr.; E. W. Varcoe, N. Y. Office Mgr.; J. W. Harris, Houston Div. Mgr.; W. G. Moser, Chicago Div. Mgr.

Sorensen & Co., Inc.,
Stamford, Conn. 512, 514

Exhibiting: New "B-Nobatron" highly stabilized source of high voltage, A-c. line regulators; "Nobatron" Fosterited transformers. Engineering service on power stabilization problems.

In Attendance: Edward R. McCarthy, Sales Mgr.; Leo Heiterline, Ch. Engr.

South Bend Lathe Works,
South Bend, Ind. 432

Exhibiting: New 14" precision drill presses, floor and bench models; 7" precision bench shaper. Precision lathes.

In Attendance: C. L. Miller, John F. Probst, R. W. Pfanck, Paul George.

Standard Electric Time Co.,
Springfield, Mass. 312

Exhibiting: New photoelectric tachometer. Timers; tachometers; jacks and plugs; custom-built electric panels for test, control and power distribution.

In Attendance: E. S. White, Asst. Sales Mgr.; Wm. Gorton, District Sales Mgr.

Herman H. Sticht Co.,
New York, N. Y. 306

Exhibiting: Megohmers, tachometers; rheostats; other electrical instruments.

In Attendance: Robert J. Sticht, Service Engr.; Arthur H. Wolker, Gen. Mgr.; Frank Dugan, R. S. Young, Sales Engrs.

Streeter Amet Co., Chicago, Ill. ... 305

Exhibiting: New recording "Scientific Counter" for research laboratories and industrial operations. "Type B" recorder; "RC Traficounter"; "JR Traficounter." Automatic weighers and weight recorders.

In Attendance: V. C. Kennedy, Pres.; V. C. Kennedy, Jr., Supv. of Engr.; R. T. Isham, Supv. of Production; Harry K. Franklin, Supv. of Service; W. R. Daniels, Sales Dept.

Superior Tube Co., Norristown, Pa. . 206

Exhibiting: New K-Monel round, elliptical and flat oval tubing for Bourdon springs. Beryllium copper, type 403 stainless, chromemolybdenum, and other analyses in shaped and round tubing.

In Attendance: H. B. Brown, Jr., Gen. Mgr. of Sales; A. M. Bounds, Ch. Metallurgist; J. B. Giacobbe, Plant Metallurgist; T. H. Briggs, Electronic Engr.; M. P. Moffitt, C. Cope, C. W. Heckler, L. M. Huston—Sales.

C. J. Tagliabue Corp., of N. J.,
Newark, N. J. 118, 120

Exhibiting: Indicating, recording, controlling instruments for temperature and pressure; "Celectray" automatic self-balancing recording and controlling pyrometers; moisture meters; instruments for testing petroleum products.

In Attendance: A. G. Koenig, Gen. Sales Mgr.; E. T. Oettinger, N. C. Munisteri, L. Van Blerkom, Div. Sales Mgrs.; F. A. Hebenstreit, L. M. Hachenberg, C. L. Huffman, Dist. Sales Mgrs.

Taylor Instrument Companies,
Rochester, N. Y. 416, 418, 420

Exhibiting: New mercury manometer with positive-acting submerged check valves, adjustable leakless damping assembly, continuous interchangeable ranges from 10-533 inches water. "Fulscope" controllers; level transmitter; flow meter accessories; indicating thermometers; self-acting temperature controllers.

In Attendance: R. E. Olson, Gen'l Sales Mgr.; F. S. Ward, Ind. Sales Mgr.; A. J. Fleig, Div'l. Sales Mgr.; J. S. Detwiler, Div. Sales Mgr.; R. E. Clarridge, Mgr. Application Engrg.; R. N. Pond, G. E. Heller, App. Engrs.; W. W. Lockwood, Adv. Mgr.

Telechron, Inc., Ashland, Mass. ... 417

Exhibiting: New timer with switch for ranges, fans, steam radiators, etc.; interval switch timer with signal. Synchronous motors and timing devices.

In Attendance: R. T. Woodward, Mgr. Ind. Sales Div.; C. B. Dix, Mgr. Motor Sales Div.; R. E. McBride, Asst. to Mgr. Ind. Sales Div.; Sales Engineers.

Test Equipment Sales Co., Inc.,
Philadelphia, Pa. 107, 109

Exhibiting: New Barton "Model 200" rupture-proof bellows-type low-differential pressure indicator; Barton flow recorder equipped with chart drive and pen mechanism; Barton mechanical flowmeters and differential pressure indicators; electronic pressure pick-ups; accelerometers; carrier amplifiers; strain gage amplifiers; power supplies; electronic test equipment; oscilloscopes; signal generators; multi-meters; etc.

In Attendance: Barton Jones, Claude B. Nolte, Alex Weiss.

Thwing Albert Instrument Co.,
Philadelphia, Pa. 412

Exhibiting: New bolometer recording on "Sentronic" recording pyrometer for more accurate measuring of radiant energy than with thermopiles; vane type temperature controller with indicator independent of control pointer; modulus of rupture tester. Electro-hydraulic tensile strength tester; treasure chest; sentronic recording pyrometers; pH meter.

In Attendance: Fred Curran, Div. Engr.; John Fachet, Prod. Engr.; R. E. Green, W. D. James, Sales Engrs.; F. W. Eitzel, Adv. Mgr.

Trimount Instrument Co.,
Chicago, Ill. 107

Exhibiting: New "Eclipse" smoke indicator; high-pressure eye-level tank gage. Multiple-tube manometer; manometers; flowmeters; electronic level control; micromanometer.

In Attendance: J. L. Mayer, Pres.; E. E. Kreml, Sec.; Alex Weiss, Eastern Rep.

Trinity Equipment Corp.,
Newark, N. J. 318

Exhibiting: Thermowells.

In Attendance: George R. Feeley, Pres.; James V. Mannion, V. P.

Triplett Electrical Instrument
Company, 135 E. College
Avenue, Bluffton, Ohio 204

Exhibiting: Electrical measuring instruments, meters and testers.

In Attendance: Massey Associates, Philadelphia Reps.

Uehling Instrument Co.,
Paterson, N. J. 409

Exhibiting: Absolute pressure indicators; absolute pressure recorders; liquid level indicators; vacuum indicators; pressure gages; draft gages; pressure and vacuum gages; mercurial barometers; vacuum recorders, manometers.

In Attendance: C. J. Schmid, Sales Engr.; Alexander Foth, Sales Engr.; P. J. Riccobene, Sales Mgr., William Justice, Pittsburgh Rep.; Larry Burroughs, Sm. Lukens of Sherman Engrg. Co., Philadelphia Reps.

Veeder-Root, Inc., Hartford, Conn. . 126

Exhibiting: New magnetic counter for remote indication; magnetic counter for installations not requiring an extremely high number of counts. General industrial counters, electrically and magnetically operated; engineered special counters.

In Attendance: J. R. Mathieson, Sales Supvr.; G. L. Logan, Div. Sales Supvr.; C. S. Palmer, Dist. Rep.

Wallace & Tiernan Products, Inc.,
Belleville, N. J. 402

Exhibiting: New portable microammeter adjustable for practically any range particularly useful in microampere ranges. Pressure-sensitive instruments.

In Attendance: Warren F. Haring, Instrument Sales Mgr.; Lester E. Demler, Sales Engr.

Weston Electrical Instrument Corporation, 614 Frelinghuysen Ave.,
Newark, N. J. 419

Exhibiting: New contact-making thermometer; resistance type temperature indicator; clamp volt-ammeter; portable d-c. and a-c. instruments; moisture-proof "Photronic" cell; speed-ratio tachometer; sensitive d-c. integrator. (All new.)

In Attendance: Lawrence F. Parsehigh, Mgr. Educ. & Public Utility Sales; Ray T. Pierce, Mgr. Process Industry Sales; Anthony Lamb, Asst. Ch. Engr.

Weatherhead Co.,
Cleveland, Ohio 143

Exhibiting: Fittings—brass, steel, stainless steel, aluminum, ermeto, inverted, compression, S.A.E., special; hose and hose assemblies; low, medium and high pressure hose; factory attached and re-usable end fittings.

In Attendance: M. C. Peterson, Asst. Gen. Sales Mgr.; Howard H. Lawson, Sales Engr.; D. R. Fairchild, Adv. Mgr.

Wheelco Instruments Co.,
Chicago, Ill. 237, 239

Exhibiting: New "Capacilog" strip-chart recorder-controller for temperature or other variables; solder tin content indicator. "Panelmount Capacitrol"; "Multronic Capacitrol"; "Chronotrol"; "Imputrol"; "Throttrol"; "Flameotrol", indicating and portable pyrometers. Engineering service on indicating, controlling and recording of temperatures.

In Attendance: Fred A. Hansen, Pres.; Chas. L. Saunders, Ex. V. P.; C. A. Gates, V. P. and Eastern Div. Mgr.; E. Schneider, Dir. of Research and Engrg.; H. W. Bluethe, Adv. Mgr.; H. Proske, N. Y. Office Mgr.; B. Ramthun, Application and Sales Engr.; R. R. Meridith, Engr.; J. C. Freyberg, Asst. Adv. Mgr.; J. Cantor, Cleveland; E. W. Heffernan, Boston; R. Channell, G. C. Holbrook, L. Roher, J. Branigan, New York; R. Smith, Washington; W. J. Olson, Buffalo; A. W. Whitaker, H. Berger, Pittsburgh; S. W. Johnson, Atlanta.

Raymond M. Wilmotte, Inc.,
Washington, D. C. 208

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AIR-OPERATED AUTOMATIC CONTROLLERS
Principles Utilized *in the* Principal Types

By WERNER G. HOLZBOCK, New York, N. Y.

ONE of the reasons for the increasing use of automatic control in industry is the improvement of *every* category of automatic-control mechanism: hydraulic, electrical, electronic and pneumatic. The use of compressed air as auxiliary power began in the nineteenth century but it was not until recent years that air-operated controllers were refined to make possible numerous modes of control fully on a par with (and some users say better than) the performance of the newer controllers. Air-operated controllers of 1948 are triumphs of design genius as compared to those of fifteen or twenty years ago; and they are, of course, more complicated. In particular, there are today many more basic *types*. (There may be more *makes*, too, but the writer will not discuss them as such. As a matter of fact, each controller manufacturer offers a choice of several types.)

The most popular form of air-operated controller is the *recorder-controller*. This article will, therefore, deal with the types of recorder-controllers, but it is hoped that much of the discussion will be applicable to indicating (and even non-indicating) controllers.

A logical way of starting this study is to list the objectives which all manufacturers of pneumatic control systems strive to attain. Disregarding instrument size and weight, corrosion-resistance, competitive features designed for ease of installation or of servicing, etc., and all other questions not pertaining to our inquiry, we find that there are *six definite objectives:*

(1) Close control of the air pressure to the final control element (valve, damper, etc.);

(2) Avoidance of backlash or lost motion in flapper and pen linkage;

(3) Minimum of sensitivity to vibration;

(4) Avoidance of dead time, i.e., delay or response to changes in the controlled variable, as far as possible and desired in any particular process;

(5) Use of small volumes of air;

(6) Linear variations in transmitted pressure.

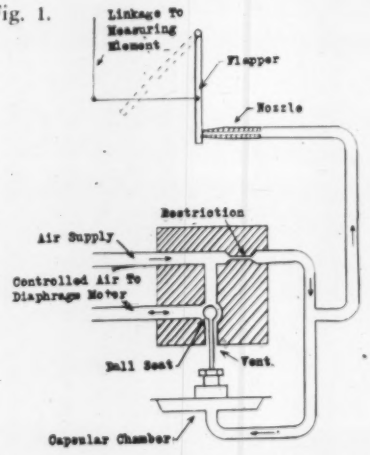
In this article the various means which are employed to obtain these six objectives are studied.

Restriction, Nozzle and Flapper.

Fig. 1 is a schematic diagram of a practical feasible pneumatic on-off controller. The pilot valve (described in a later paragraph) is introduced to relieve the air pressure from the flapper as far as possible. Only if this pressure is kept at a minimum can a satisfactory attainment of the above-listed objectives be possible.

The sensitive measuring system positions the flapper through a linkage so that the flapper will either cover or uncover the nozzle. The power of the measuring system being extremely low, the air pressure against which the flapper has to work must be kept correspondingly low in order to avoid destroying the sensitivity of the instrument.

Fig. 1.



The air pressure applied to the diaphragm motor must be high enough to assure positive operation of the valve or other final control element. A pressure change from 2 to 15 (or 2 to 20) lbs./in.^{2} suffices to operate the usual final element positively and satisfactorily, but in some cases this pressure is relayed to higher pressures in order to operate a large final control element or one handling high-pressure steam, viscous materials, etc.

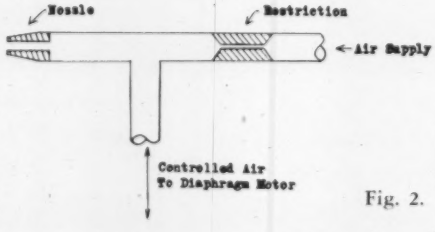


Fig. 2.

Since a pressure of 15 to 20 lbs./in.^{2} is too high to apply *directly* to the flapper, the pilot-valve principle is utilized to make it possible to control the air flow to the diaphragm motor with only part of the pressure of the air supply.

A restriction in the air line to the nozzle reduces the air pressure. The diameter of this restriction is made small; not so small, however, that the slightest impurity in the compressed air might plug it up. Restriction diameters range from 0.007″ to 0.010″. The Brown Instrument Co., for example, uses a restriction of 0.008″ diameter which reduces the supply pressure at the nozzle to 5.5 to 6 lbs./in.^{2} when the flapper covers the nozzle.

The nozzle diameter is about twice the diameter of the restriction. The previously-mentioned Brown Instrument Co., for example, uses a nozzle of 1/64″ or approximately 0.0156″ with their restriction of 0.008″ diameter. This means that the maximum pressure applied on the flapper, would amount to a total pressure of only approximately 1/3 ounce—a result obtained through the application of a pilot valve and the utmost reduction in the nozzle diameter.

The Bristol Company uses a larger diameter for nozzle and restriction: 0.023″ for the nozzle and 0.013″ for the restriction. In this case, the maximum nozzle back pressure is 10.5 lbs./in.^{2}. This higher back pressure does not mean any undue stress on the mechanism, by reason of the "Free Vane," a vane exposed to the nozzle pressure on both sides by the application of twin nozzles. While the "Free Vane" means reduced stress on the flapper, it increases the loss of air through the nozzle by 8 to 12 times, in comparison with other designs, because the nozzle back pressure is three times that of other designs and the nozzle area more than four times.

The reason for the difference in diameter between nozzle and restriction is that flow of compressed air has to be faster through the uncovered nozzle than through the restriction. Only by this means can the desired change in pressure difference between covered and uncovered nozzle be obtained. When the nozzle is covered by the flapper, the pressure between nozzle and restriction becomes a maximum; in the above-mentioned example, this would mean a pressure of 3 to 3.5 lbs./in.^{2}. As soon as the flapper uncovers the nozzle, this pressure is expected to fall rapidly. The larger the nozzle, the better can this be accomplished. But again, the larger the nozzle, the heavier the total pressure on the baffle. The accepted solution is a nozzle about twice the diameter of the restriction.

The Pilot Valve.

The pilot valve makes possible the application of a higher pressure on the final control element than on the nozzle, but there are other reasons for the use of a pilot valve. Fig. 2 shows part of a pneumatic controller without a pilot valve. When the flapper covers the nozzle by reason of a movement of the measuring system caused by a change in the controlled variable, the pressure behind the restriction will increase and

cause the desired action of the final control element, say a diaphragm motor. All the air necessary to increase the pressure in the line to the diaphragm motor and above the diaphragm would have to flow through the restriction—whence a considerable delay in corrective action. To avoid this delay, the air necessary for the increase in pressure in lines and parts outside of the instrument, should not be throttled by a restriction. This also calls for a pilot.

It stands to reason that no decrease in air pressure is possible in a pneumatic controller without bleeding the excess air to the atmosphere. Even the so-called non-bleed pilot valve does not altogether eliminate this loss.

In the position shown in Fig. 1, no bleeding of air takes place as the ball valve rests on the lower seat: the pilot valve is fully open and the controlled-air pressure is equal to the supply-air pressure. When the ball valve is pushed against the upper seat, the pilot valve is fully closed. Excess air from the line to the diaphragm and above the diaphragm itself will flow out but then no further bleeding occurs. This condition is entirely satisfactory for on-off control, but the situation changes in the case of control methods in which the ball valve takes an integral number of steps between the upper and lower seat: in all these intermediate positions, the supply line will bleed constantly through the vent to the atmosphere. The loss is relatively small. A hundred pneumatic controllers will seldom require an air consumption involving more than 3 to 4 kwh. in the compressor. (It is doubtful if this consumption can be cut by more than half, even through the most refined construction of a non-bleed valve which avoids bleeding in the intermediate stages of pilot valve opening.)

Fig. 3 is a diagram of a non-bleed type of pilot valve (Brown Instrument Co.). In comparison with the above-described continuous-bleed type, this design provides that the vent is always closed as long as supply air is admitted, even if the supply port is only partly opened. Detailed functions will be described below.

Continuous-bleed type pilot valves (Fig. 1) usually have a provision for adjusting the stem travel. This adjustment determines the point at which the pilot valve starts to open (or, in a reverse-acting pilot valve, to close). The stem travel must be kept as short as possible to reduce air consumption. A travel of 0.01″ is general practice.

It is a characteristic of the non-bleed type (Fig. 3) that it requires larger dimensions which allow a quicker supply and relief of controlled air through the pilot valve.

The non-bleed type of pilot valve (for example Brown Instrument Co., Fig. 3) uses a bellows system. The controlled air pressure as applied in the final control element is also applied to the smaller bellows. To the larger bellows, the nozzle back pressure is admitted. The maximum nozzle back pressure is about one-fifth of the supply pressure. The larger bellows, being under the nozzle back pressure, has a surface five times the smaller bellows under the controlled-air pressure. When the system is in a balanced position, the nozzle back pressure on the larger bellows balances the higher pressure on the smaller bellows and the pilot-valve flapper covers both the supply and exhaust ports.

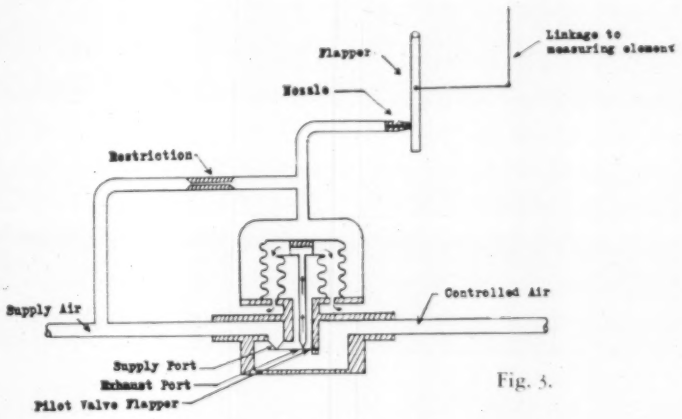


Fig. 3.

With an increase in the nozzle back pressure, resulting from a deviation of the controlled variable from the control point, both of the bellows move forward. This bellows carries the exhaust port which pushes against the pilot-valve flapper, thus opening the supply port, while the exhaust port remains closed. With a decrease in nozzle back pressure, both of the bellows back away. This opens the exhaust port leaving the supply port closed by the pilot valve flapper. Thus, the change in nozzle back pressure is amplified through the pilot valve and produces a change in the controlled-air pressure to the final control element.

Non-bleed valves present a difficulty which good design reduces to an unobjectionable minimum. This is the so-called dead spot which originates from the following facts: The pilot valve flapper is under the constant pressure of a spring. The exhaust port, which moves up and down, positions the pilot-valve flapper so that it has to overcome the spring pressure. Starting from a position in which the pilot-valve flapper covers both the exhaust port and the supply port, the force necessary to open the supply port is not obtained by any increase in nozzle back pressure but by an increase large enough to overcome the pressure of the spring. The range of pressure change without response in the pilot valve is called dead spot. Moreover, hysteresis may occur because of the fact that the opening of the supply port is *against* the spring pressure while the closing is *with* the spring pressure.

Two means are employed to minimize dead spot. The first is to have the smallest possible spring tension (which, however, has to be large enough to provide a positive shut-off of the supply port). The second means is to make the force which moves the exhaust port large in relation to the spring tension. Therefore, the larger the bellows the more nearly perfect is the solution.

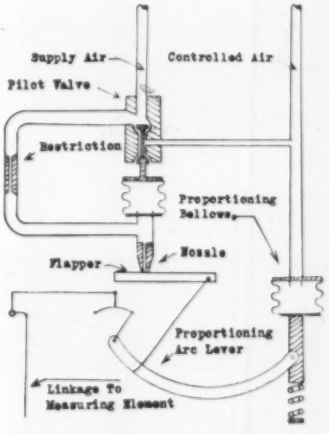


Fig. 4.

The Mason-Neilan pilot valve (Fig. 8) may be mentioned at this point, as an example of a continuous-bleed type with a bellows systems in contrast to the usual combination of a capsular chamber and valve stem.

Proportional-position Action.

Automatic controllers can be divided according to modes of control into the following four "groups" (which are not always distinct "types" because one instrument may be changed from one group to another):

(1) Two-position action
(2) Proportional-position action
(3) Floating action
(4) Proportional-plus-reset action

Following usage, we shall nevertheless call them types. Type 4 is, of course, the combination of types 2 and 3.

The characteristics in the design of nozzle, restriction, and pilot valve, as heretofore described, refer to any of these four types, but additional means are necessary to accomplish any of them. They all hinge on the problem of controlling the movement of the flapper—a linear movement of, generally, only 0.002″. This small movement is sufficient to fully open the nozzle; and, if intermediate positions are desired, they have to be found within this 0.002″.

For proportional-position action two conditions have to be fulfilled. (1) The flapper must hold an infinite number of positions between on and off, and (2) as the flapper is moved by the measuring unit through a linkage, the flapper movement from open to closed nozzle has to have a definite relation to the variations in the controlled variable. The range of values of the controlled variable which corresponds to the range of flapper action is called the proportional band. It is, generally, expressed in percent of full scale range

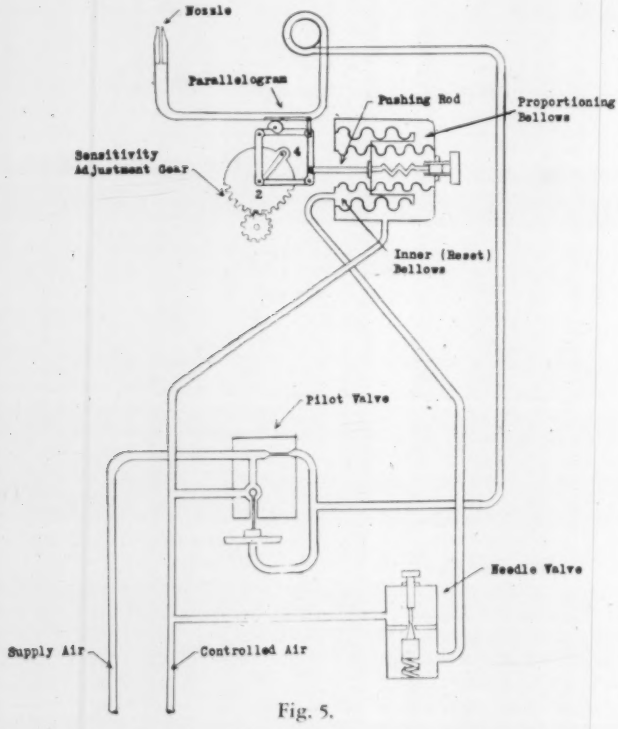


Fig. 5.

of the controller required to produce full operating range of the final control element.

On some instruments it is possible to get a 10% proportional band without a special mechanism but for higher sensitivities special mechanisms are employed. It must be realized that with total flapper range of 0.002", the flapper must be positioned accurately within 0.00002" when a change in control pressure of 1% is desired with 100% throttling range. As a matter of fact, the maximum sensitivity in actual instruments is much higher than that.

This problem is solved by a mechanism which exerts a countermovement to the action of the flapper when it starts to uncover the nozzle. And the more the flapper tries to uncover the nozzle, the more the countermovement must increase, making it possible to achieve each time a perfect balance of counteracting forces by a small differential which positions the flapper exactly.

The countermovement to the action of the flapper can be put into the flapper itself or into the nozzle. Flapper action is used by most manufacturers except Taylor Instrument Co. (Another design, as used in Leeds & Northrup instruments, differs from the conventional nozzle and baffle principle. This system, called pneumatic balance, will be described at the end of this article.)

Fig. 4 is a schematic diagram of a proportional controller (the Foxboro). When the flapper closes the nozzle, owing to a motion of the measuring element, the increased nozzle back pressure causes the pilot valve to open. Consequently the pressure of the controlled air increases. This increase in pressure is not only transmitted to the final control element but at the same time to the proportioning bellows which, through an appropriate linkage, exerts an effort on the flapper in the opening direction, i.e., opposite to the original movement of the flapper.

If this counteracting force of the proportioning bellows were equal to the force exerted by the measuring element, no flapper movement would take place at all. If the counteracting force were infinitely small, no delaying or balancing action would occur: a small impulse from the measuring element would move the flapper from fully open to fully closed, or vice versa, and no proportional band would be available.

There are then the two extremes of proportioning bellows action: (1) Acting force of proportioning bellows is equal to impulse received from measuring element, resulting in no response of flapper; (2) Acting force of proportioning bellows is nil, resulting in on-off control. Therefore, on-off control is only one extreme of proportional-position action. It is equal to a maximum of control-sensitivity, just as no control is a complete lack of control-sensitivity. Between these two extremes, the regulation of the proportional band is possible. The amplitude of the proportional band increases the nearer one gets to extreme (1). This change is accomplished in the Foxboro proportional controller by moving the link beneath the flapper along the arc lever, thereby changing the relation of forces acting on the flapper.

Fig. 5 is a schematic diagram of another proportional system (Taylor). This also taps the controlled air, and transmits the necessary counteracting force to the nozzle by means of a bellows. The proportional band is adjusted by means of a parallelogram system of levers which transforms the horizontal movement of the bellows into a smaller or larger vertical movement of the nozzle.The control-sensitivity adjustment gear allows a manual change in the angular position of the legs which form the parallelogram. By turning the control-sensitivity adjustment gear the movable pivot 4 riding on the perimeter of the circular gear moves in a circle around point 2. Once the adjustment is made, point 4 may be at any of the locations given in sketches

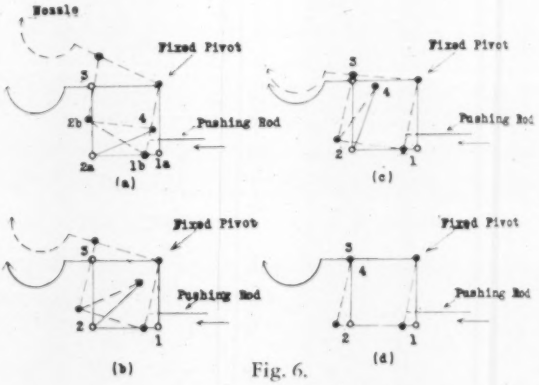


Fig. 6.

6a, 6b, 6c, or 6d, or any intermediate position. Suppose the position is as in 6a. The pushing rod is moved forward by the action of the proportioning bellows. The original position is shown by a full line, the final position, caused by the maximum movement of the pushing rod, is indicated by the dotted line drawn from point 1b to the fixed pivot. The distance through which the nozzle is lifted is directly related to the movement 2a to 2b. The movement 2a-2b depends on the position of point 4 which is set by the sensitivity adjustment gear. Drawing an imaginary line between 4 and 1a, one could say that the longer the distance 4-1a in relation to the fixed distance 4-2a, the smaller will be the movement of 2a-2b in relation to 1a-1b, i.e., the larger will be the distance through which the nozzle moves upon a given movement of the pushing rod. As the distance 4-1 increases through 6b, 6c, and 6d, the nozzle movement decreases, being zero in 6d. Fig. 6d would then correspond to high proportional sensitivity or small proportional band—practically off-on control—while Fig. 6a means a low proportional sensitivity or a large throttling range (approximately 400%). The intermediate

positions are integral and selected by the control-sensitivity adjustment gear.

Fig. 7 shows a proportional controller (Brown) in which the bellows system moves the flapper instead of moving the nozzle. When the controlled air pressure rises, owing to the flapper closing the nozzle, the counter-action of the bellows tries to pull the flapper from the nozzle, and as a consequence, the flapper covers the nozzle less than it would without the counteraction. Fig. 7 shows a pushing rod which moves backward and forward by the action of the bellows. This movement is transmitted through pins over a wedge-shaped metal piece and a throttling arm to the throttling linkage. The throttling linkage is connected to the flapper-actuating lever, where it buffers the action from the pen linkage. The balanced differential of both movements positions the flapper.

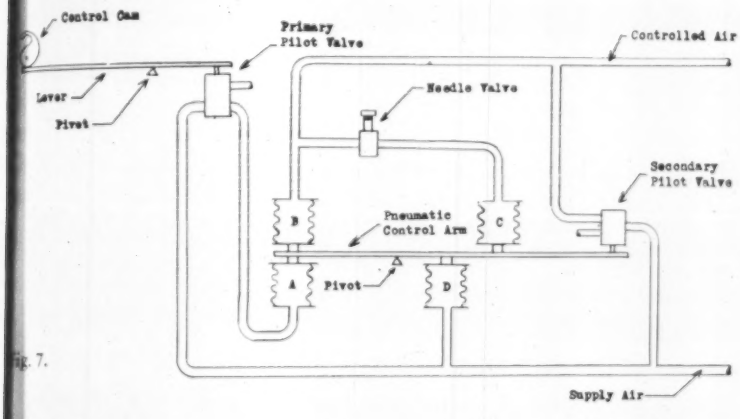


Fig. 7.

The throttling arm is moved by the action of the pushing rod in a circular movement around a fixed pivot at its upper end. Consequently, the linear movement of the throttling arm will be the largest on its lower end and decreasing toward the top. There is a pin between the throttling arm and the throttling linkage, by which the movement of the throttling arm is transmitted to the throttling linkage. This pin can be positioned by the throttling-range* dial as indicated in Fig. 7. The further down the pin is moved the larger will be the linear distance through which it is moved by the action of the pushing rod, and, as a consequence, the larger will be the action on the flapper-actuating lever. The result is decrease of control-sensitivity, increase of proportional band.

One Taylor proportional-band mechanism has been described. This manufacturer uses also another system, employing a diaphragm instead of the bellows, and changing the angular movement of the flapper instead of placing the parallelogram adjustment between bellows and nozzle.

*The author uses both terms: "proportional band" and "throttling range"—the choice depending, for the convenience of readers, on the usage of the manufacturer whose control mechanism is being discussed.

In another system (Mason-Neilan Regulator Co.), the counteracting force to the flapper movement is obtained by a Bourdon tube connected to the flapper and acting under the controlled air pressure. The special feature lies in the Bourdon tube. In one model, the same principle is used for a *secondary* pressure compensator, of which Fig. 8 is a schematic diagram. If, for example, the controlled variable is temperature and the controlled medium is steam, variations in the steam pressure could be controlled by the methods so far described, and a change in temperature would be unavoidable. For this reason, the second Bourdon tube acts, as the first one does, upon the flapper.

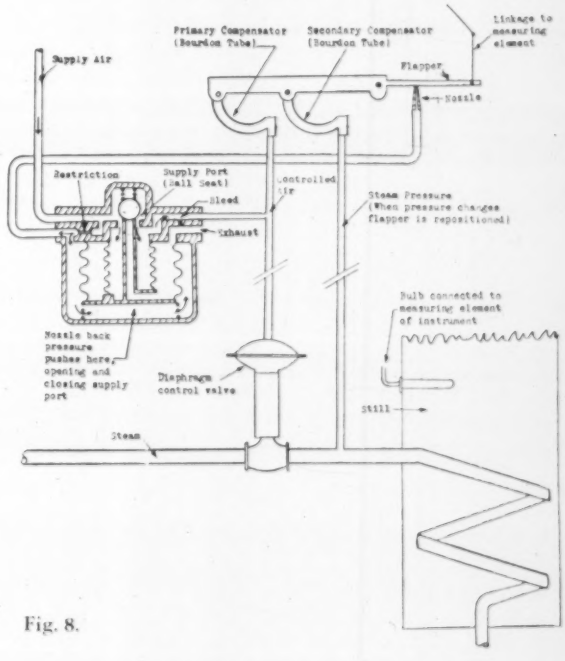


Fig. 8.

The second Bourdon tube would, in this example, be connected to the steam pressure. If this pressure rises, the flapper opens a small additional amount and the final control element, namely the valve, closes in proportion to the change in steam pressure.

Load Error, or Droop

One of the problems in automatic controllers is elimination of "droop" or load error. The following example explains this phenomenon: The outlet temperature of a steam-heated still is to be controlled at 140°F. The final control element is a direct-acting diaphragm steam valve so calculated with regard to *normal* liquid flow and to *normal* steam pressure and quality that, at exactly 50% valve opening, it will provide the correct steam flow to maintain the desired temperature. The range of the instrument is from 0° to 200°F. and the proportional band 20%. This means that the valve will be fully open at 120°F. and fully closed at 160°F.

Suddenly the flow of liquid through the still is greatly increased. Under the original condition, a 50% steam valve opening maintained the outlet temperature at 140°F. The increased liquid flow would, of course, call for more steam (more Btu's per second) than before the change. Suppose this requires a 60% valve opening instead of the original 50%. With the methods so far described, there is no means of changing the setting in such a way as to change the valve opening from 50% to 60% in order to maintain the outlet temperature at 140°F. The outlet temperature will be below 140°F. not only momentarily (as with even an "ideal" controller) but as long as the liquid flow exceeds the normal flow on which the valve calculations were based.

Similarly, there will be a permanent error if the steam temperature, pressure and quality is permanently changed.

The relation between Btu. demand and Btu. supply, or, in general, the relation between demand and supply in any application, is the load factor. The error resulting from a change in either is the load error. One device described above (the "dual compensated" controller made by Mason-Neilan Regulator Co.) solves the stem-pressure-change automatically, but this and similar systems do not represent complete solutions of the load-error problem.

Manual Reset.

The necessary solution of the load-error problem could be described in this way: To design a means whereby the center of the proportional band can be shifted in relation to the original set point. There are numerous designs for accomplishing this automatically as well as manually. A manual reset (Brown Instrument Co.) will be described first. It can be seen from Fig. 7

that by turning the manual reset screw, a wedge-shaped metal piece will be raised or lowered. The effect is a relative prolongation or shortening of the pushing rod of the bellows, whereby the flapper will be moved an additional amount. In the above example, where a change of valve opening from 50% to 60% was required to maintain the temperature at the set point, it would be necessary to lower the wedge-shaped metal piece by means of the manual reset dial by a definite amount and the flapper would move away from the nozzle somewhat. As a consequence, the controlled air pressure would decrease and give the valve the desired additional pressure for an opening of 60%.

Automatic Reset.

Referring again to the above example with the starting conditions of 50% valve opening and outlet temperature controlled at 140°F. it was found that when the flow of liquid through the still increased, the valve opening of 50% was no longer sufficient to maintain the temperature at the set point. Let us give additional figures to bring out automatic reset. As the first controller reaction to the 10° drop, from 140°F. to 130°F., the valve opened 75%, the temperature started to go up again, and the valve, in proportion thereto, started to close. At 136°F., the valve was 60% open. This, as mentioned, was the opening that could maintain a temperature of 140°F., but the valve could not stay there, because any approach to this temperature would close the valve below 60% and approaching 50%. Consequently, without manual or automatic reset the temperature remains below the set point of 140°F.

Automatic reset endeavors to provide a force which is available whenever the temperature deviates from the set point, and which assists the movement of the nozzle opening, amplifying the tendency of opening or closing the same.

As a result, in the foregoing example, the temperature would first tend to drop to 130°F., the valve would first tend to open to 75%, as before, and the temperature would rise, as before; however the closing action on the nozzle would *not* be in proportion to the temperature increase, but would be *delayed* by the action of automatic reset. The temperature would finally come back to 140°F., but with a valve opening of, say, 65%, owing to the *delaying effect* of the automatic reset, and as a consequence of a 65% valve opening, the temperature would increase above 140°F., i.e., above the set point. However, if the temperature increase exceeds the 140°F. mark, a corrective action would be initiated by the measuring element of the instrument; again the automatic reset would cause a delaying effect, and the temperature of 140°F. might again be exceeded by a certain amount, this time by, say, 2°F. Corrective action is once more initiated. This cycling around the set point can be reduced to a minimum by adjusting the amount of the automatic reset, known as the reset rate. There is no universal mathematical formula for determining the reset rate beforehand. It depends upon the conditions of each individual process and adjustments must be made in the field.

With the devices so far described, the opening of the nozzle is determined by three forces:

(1) Through the measuring element in the instrument by means of a linkage.

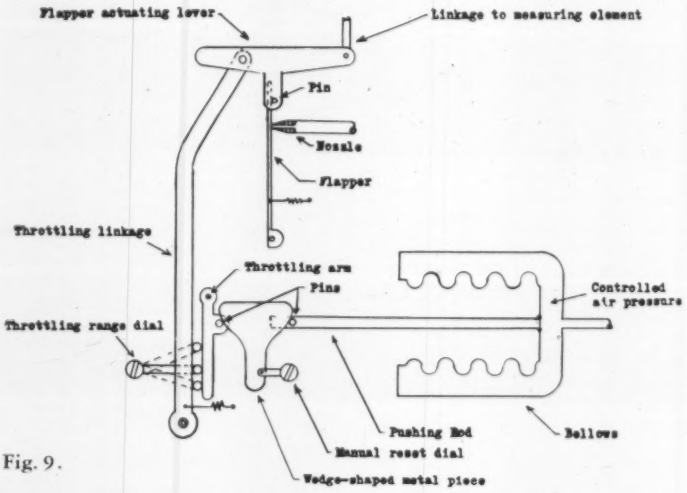


Fig. 9.

(2) Through the controlled air pressure, counteracting the force of 1 and decreasing its effect proportionally. This force is transmitted by a bellows system or, in one case, by a Bourdon tube.

(3) Through the controlled air pressure, assisting the force of 1 in proportion to the deviation of the controlled variable from the set point.

Action 3 is then opposite to 2 and this fact is used in the design of automatic-reset mechanisms. Fig. 5 shows the same bellows as for proportional control (as used by Taylor Instrument Co.), but an inner bellows is added, connected through a needle valve to the controlled air pressure. By means of this needle valve, the adjustment can be made which was described above and which determines the reset rate.

Practically all manufacturers of air-operated controllers use the same principle. Action 2 of the bellows has to be counteracted by a second system of bellows which stands for action 3. A differential of force has to exist between action 3 and action 2, making it possible to open and close the nozzle in an exact proportion.

Pneumatic Balance

The Leeds & Northrup design differs somewhat from those described in the foregoing. Instead of a flapper-and-nozzle arrangement, there is a primary pilot controlled by an eccentric control arm, connected to the measuring system of the instrument. See Fig. 9. The control arm raises and lowers a lever which opens or closes a pilot valve, admitting more or less air to bellows *A*. As the air pressure in bellows *A* increases it tends to open the secondary pilot valve by means of the pneumatic balance arm against which bellows *A* pushes. When the secondary pilot valve opens, the controlled air pressure will increase, and controlling action takes place. However at the same rate as the controlled air pressure increases, the pressure in bellows *B* increases also and as it counteracts bellows *A*, it decreases its control-sensitivity and provides proportional control. Automatic reset is provided by bellows *C*. It starts to increase or decrease its pressure practically at the same time as bellows *B* does, but continues at a slower rate. It thereby amplifies the action of bellows *A*, and this amplification will be the larger, the longer time the corrective action takes place, i.e., the larger the deviation of the controlled variable is from the set point.

Bellows *D* actually counteracts the action of bellows *A*. When the primary pilot valve is half open, the controlled variable is at the set point. Under this condition, bellows *A* and *D* balance each other, because bellows *D* is only half the distance from the pivot of the pneumatic balance arm as is bellows *A*. As a consequence, this arm is exactly in a horizontal position. Any increase or decrease in the opening of the primary pilot valve changes the pressure which bellows *A* exerts on the arm above or below the pressure from bellows *D*, and as a consequence turns the arm around the pivot by a small amount.

This article has been, necessarily, incomplete as to makes, but an attempt has been made to explain in simple terms the basic principles of operation of those *types* which are most widely used in industry.

Note.—The Leeds & Northrup Company advises us that "the author describes a model of pneumatic control which is now obsolete with our Company. We have recently placed on the market a new and improved type of pneumatic control but our literature on this product is not yet completed . . ." —Editor.

Operation *and* Care *of* Circular-scale Instruments

By JAMES SPENCER, Meter Division, Westinghouse Electric Corp., Newark, N. J.

PART II

A-C. AMMETERS AND VOLTMETERS

Circular-scale a-c. ammeters and voltmeters are designed for circuits of commercial frequencies. Their construction is such that both mechanically and electrically they will stand hard usage over a long service life. With the added features such as simplicity of design, ease of repair, etc., no accuracy characteristics of instruments have been sacrificed.

Application.—These instruments were designed for general switchboard service where space is at a premium and ease of readability is a demand. Miniature switchboards, benchboard-type control panels, test benches and switchboard truck panels are just a few of the many applications where these easy-to-install space-conserving instruments may be used to advantage.

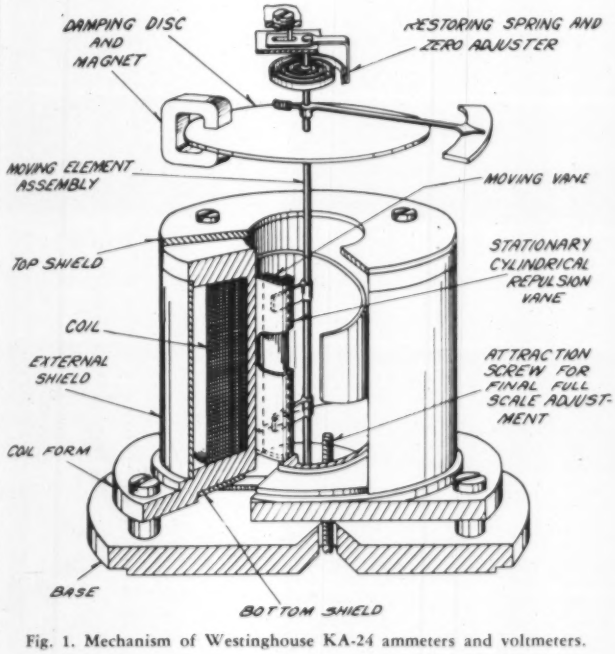


Fig. 1. Mechanism of Westinghouse KA-24 ammeters and voltmeters.

Principle of Operation

The circular scale a-c. ammeters and voltmeters operate on the repulsion-attraction principle. This principle involves the laws of magnets, that is, like poles repel and unlike poles attract.

The actuating mechanism includes three soft (non-residual) iron members and a fixed coil. These soft-iron parts are a concentric stationary vane, a movable vane and a screw-type iron rod. The deflection of the movement is controlled by a spiral spring and an aluminum vane moving in the field of a permanent magnet provides damping.

When the coil of the instrument is energized, the three soft-iron members become temporary magnets by reason of their position in the field of the coil. The fixed vane and the vane attached to the pointer shaft become magnets having like poles adjacent, while the adjacent pole of the attraction screw has an opposite polarity. To better understand the relative positions of these iron members, see Fig. 1. The fixed vane is so angulated that at the zero end of the scale the moving vane is shielded against magnetic effects of the attraction screw. Owing to this arrangement, the rotation of the moving vane over the first 180 degrees of the scale is the result of the repelling force between the moving and stationary vanes. The forces of attraction between the moving vane and the attraction screw are active in the upper part of the scale, that is, from 180 degrees to full-scale.

The a-c. ammeters and voltmeters of the AB-12 type shown in Figs. 2, 3 and 4 are also moving-iron type instruments operating on the attraction-repulsion principle. The system of iron members for producing pointer deflection in the instrument shown in Fig. 5 differs however from the instrument shown in Fig. 1 as can be seen by comparing the two sketches.

In the instruments shown in Figs. 2 and 3, the central vane exerts a force of repulsion by reason of its narrowing vane width while the upper and lower vane, owing to their increasing vane width, have an attraction effect.

The cup-shaped shields over the ends of the coil increases the permeability of the field and hence increases the instrument sensitivity.

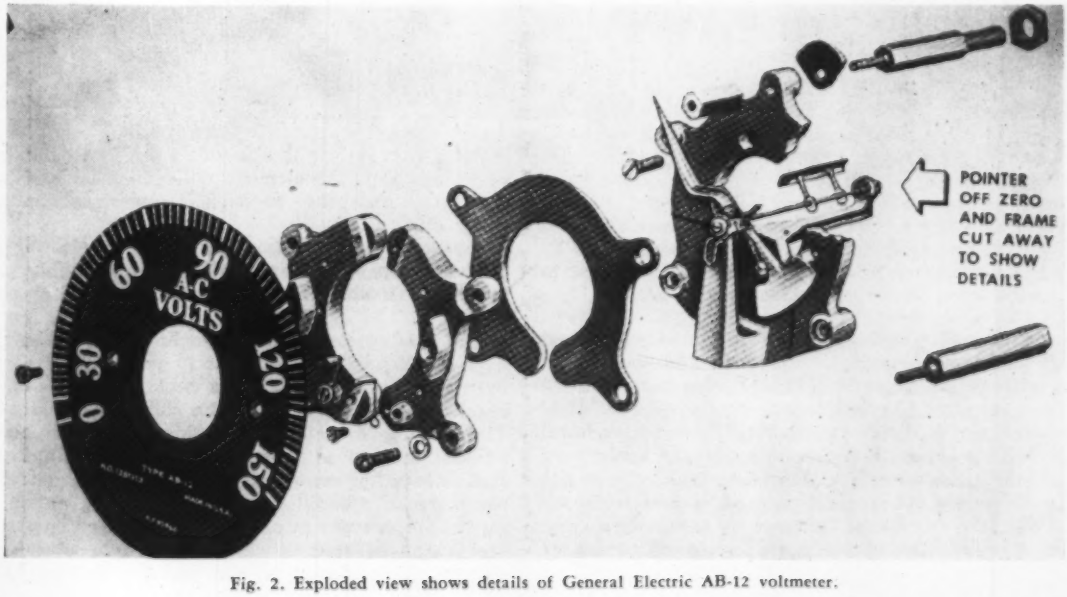


Fig. 2. Exploded view shows details of General Electric AB-12 voltmeter.

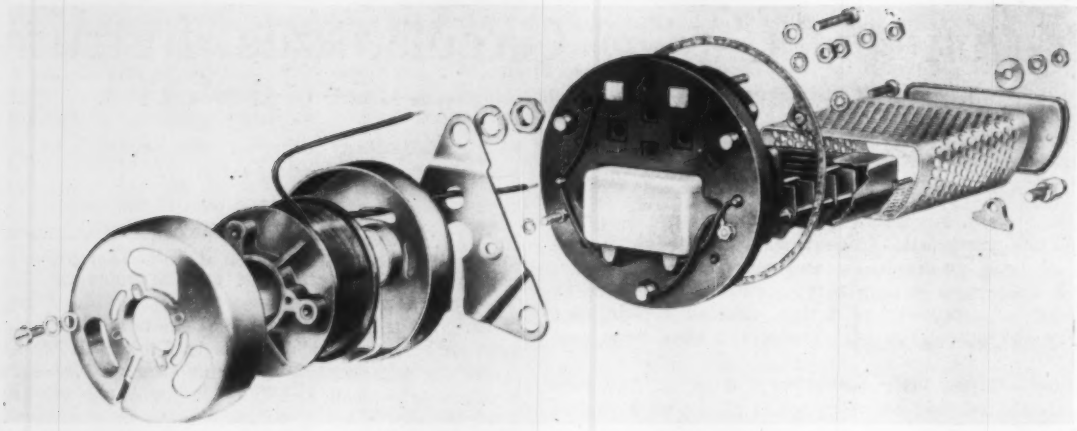


Fig. 3. Another view of components of the G-E. AB-12 voltmeter.

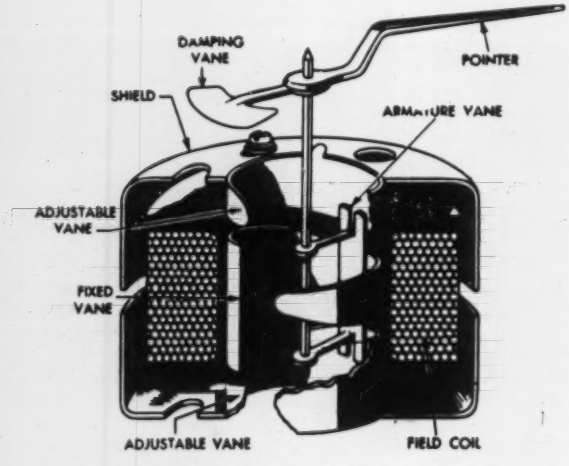


Fig. 4. Diagram showing the mechanism of the General Electric AB-12 a-c. ammeter and voltmeter.

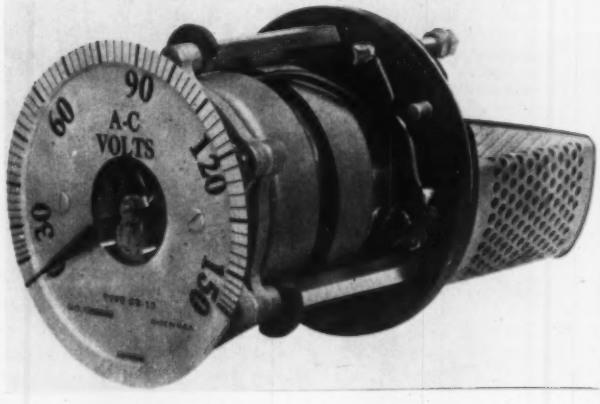


Fig. 5. The AB-13 voltmeter shown with the cover removed.

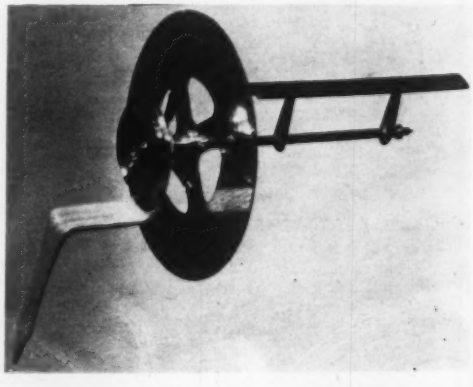


Fig. 6. Moving element assembly of a Westinghouse KA-24 instrument.

Construction

Instrument repairs usually mean the disturbing of the mechanical assembly; therefore, a maintenance and service man in this field should have a knowledge of instrument constructions. Since the repair of an instrument starts with dismantling, it might be well to use this method in outlining the principles of construction.

Dismantling KA-24 Instrument

The eight steps listed below cover the complete dismantling of an a-c. high-shock instrument to the point of its various sub-assemblies.

1. Remove cover—four screws.
2. Remove case—four hex nuts, lock washer and triangular washers.
3. Remove dial—the same as d-c. (see Part I).
4. Remove base—four hex nuts on mounting studs and nuts holding terminals to base.
5. Remove magnet—four screws hold magnet to top bridge. After removing screws, rotate ratchet zero adjuster until spring clamp is in top center position; move pointer by hand to this same position and slide magnet assembly out in the direction between the zero and full-scale points of the dial.
6. To remove coil assembly, remove four filister head screws and four hex mounting studs that hold coil bobbin flange to frame of instrument. Coil assembly may now be removed from element housing.
7. To remove movement from bracket, loosen upper jewel screw, *but don't remove*. Loosen spring clamp screw and slide spring end out of clamp; loosen lower jewel clamp nut and turn jewel screw out until movement is free to be removed. Movement may now be removed by carefully sliding it out through the bottom of the frame housing. The pointer must be in position at approximately one-third scale and moving iron on right side of lower jewel bracket arm, in which position the element will slide out easily. *With the element in any other position it cannot be removed without being damaged.*
8. There now remain the seven basic sub-assemblies, namely: base, case and cover, coil assembly, bridge and bracket assembly, magnet assembly, moving element and dial.

The moving element can best be explained by referring to Fig. 6. All parts are accurately positioned in manufacture by the use of special tools and gages. The moving-iron brackets are positioned on the shaft and soldered to same. The moving iron is then soldered to these brackets. The pointer and cross arms, spring and damping disk are staked together on an aluminum bushing, after which this assembly is pressed on the shaft. The upper and lower shaft bumpers are small bushings pressed on the shaft. The pivots are pressed in the hollow ends of the shaft. The weight of the moving iron is counterbalanced by solder un-

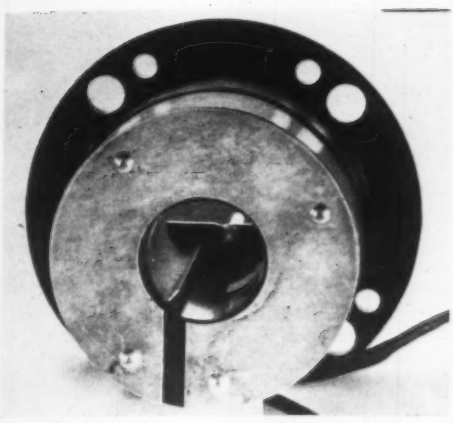


Fig. 7. KA-24 stationary coil showing repulsion and attraction iron assembly.

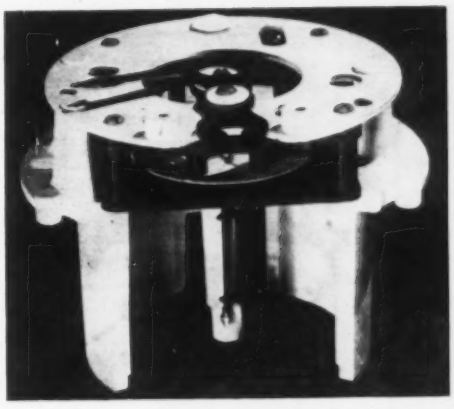


Fig. 8. Cutaway view of KA-24 element assembled in frame with damping magnet.

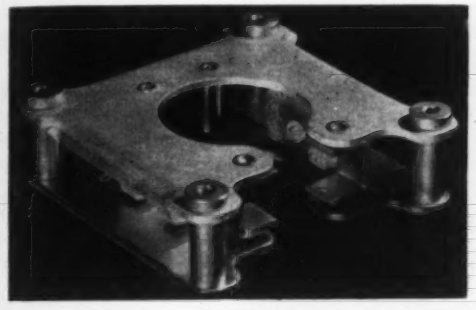


Fig. 9. KA-24 damping magnet assembly.

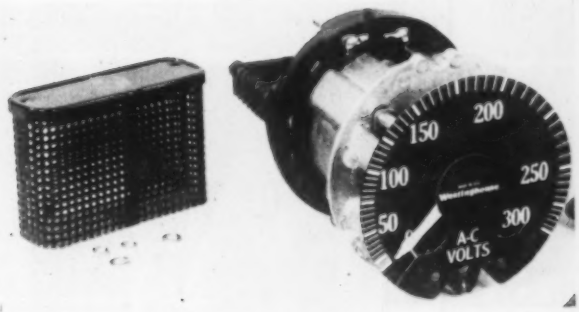


Fig. 10. KA-24 voltmeter with cover and case removed.

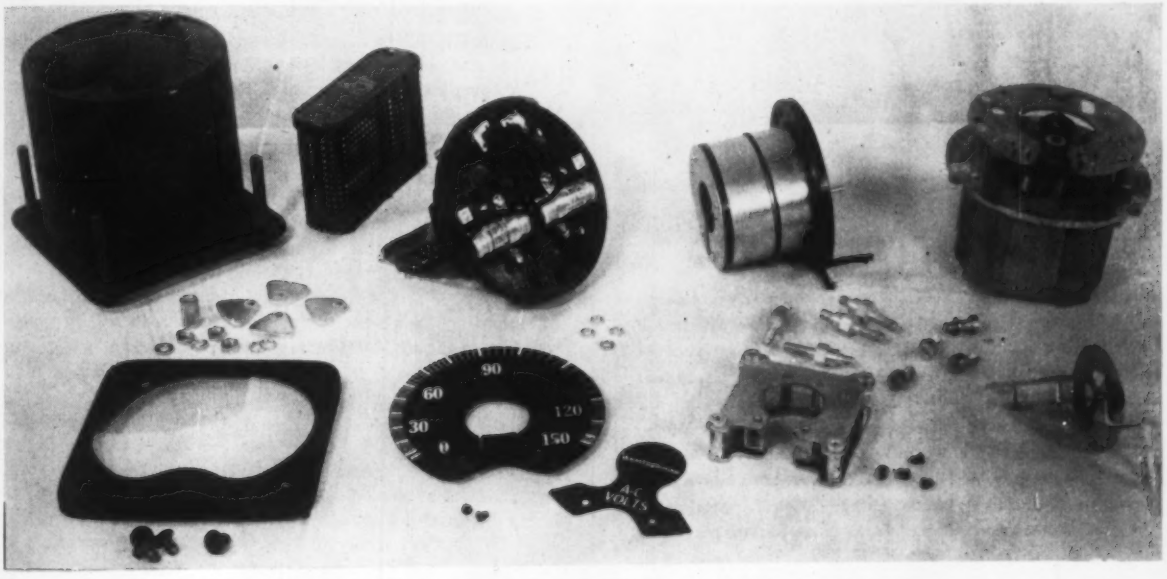


Fig. 11. All the parts making up a Westinghouse KA-24 voltmeter.

der the end of the pointer, and the three balance weights on the cross arms and the tail piece are used as trimmers.

The activating element of the circular scale instrument is shown in Fig. 7. This assembly consists of the molded bobbin on which the coil is wound and the complete shielding arrangement. The concentric stationary iron is cemented in place in the hollow core of the coil bobbin and the calibration adjusting rod with its mounting is shown at the flanged end of the bobbin.

Fig. 8 shows the element assembled in the bridge and bracket assembly of the a-c. ammeter and voltmeter. The top bridge with its jewel and zero adjuster assembly is similar to that of the d-c. high-shock instrument. The cast frame is designed to house the coil assembly with provisions as shown for attaching the coil bobbin to the frame. The lower jewel arm is tapped for assembly of the jewel screw and the screw is held tight by a lock nut.

The damping magnet assembly, Fig. 9, is positioned between the top bridge and the frame, and is held in place by four screws through the bridge plate. This magnet assembly consists of two high coercive magnets mounted in a brass type frame. The magnets are welded to the upper plate of the frame. The two studs and the two U-shaped brackets riveted to the top plate are buffers to prevent bending of the disk in case of a heavy shock. The complete assembly is staked together at the four spacer posts—one at each corner.

The case, cover, base and dial (see Figs. 10 and 11) of this a-c. instrument are similar to those of the d-c. instruments of this type. The base differs slightly, however, (see

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Fig. 12. KA-24 voltmeter base assembly showing capacitors and resistors.

Fig. 12) in the terminal and drilling arrangements, and the use of capacitors and resistors in the a-c. voltmeter.

Reassembling

To reassemble the movement, the reverse of the dismantling should be followed. To position the movement the spring clamp should be set at the mid-scale point, with the pointer at the zero position. With these settings the spring should be assembled and tightened in the clamp. With the spring clamp in this mid-scale position, move the pointer to a position just above the spring clamp. The magnet may now be slid into position and screwed to the top plate. The position of the element may now be finally adjusted, as the magnet serves as a reference point in centering the damping vane. To center the disk, adjust the jewel screws and at the same time adjust end play (see Part I).

The coil is next assembled in position and made tight to the frame by four filister head screws. The four instrument-to-base studs are next assembled and the base attached.

To complete the assembly, the dial is mounted following the same precautions as outlined for the d-c. instrument and the cover and case are assembled.

Dismantling AB-12 Instruments

A suggested sequence to follow in dismantling the AB-12 instrument shown in Figs. 2 and 3 would be to remove the *cover*, *case* and *dial* all of which operations are the same as explained for the instrument in Fig. 10.

The two C-shaped case brackets to which the bumpers are attached serve as mountings for the *damping magnets* and may be detached by the removal of the two screws through each of the wings of the casting. This operation also frees the magnet pole ring, allowing for its removal.

Three screws hold the *base* to the mechanism posts, two of which are below the resistance cards in the case of the voltmeter, hence the necessity for removing the resistor screen to loosen. To complete the removal of the base, the leads from the element to the base must be unsoldered.

With the removal of the three screws through the top bridge plate, the element may be lifted up and out of the coil assembly.

The bridge and bracket is a one-piece casting and is attached to the base by three mounting studs. A triangular Micarta spacer is assembled between the bridge plate and each of these studs, and projects beyond the bridge plate acting as a bumper between the case and the mechanism. The *movement* can be disassembled from the element bracket by freeing the clamped spring and loosening the jewel screws. The pointer, cross-arms and damping vane of the movement are together and pressed on the element shaft. The flat iron moving vane is soldered to a V-shaped bracket which in turn is soldered to the shaft. The control spring is soldered to a split bushing type collet that slides on the shaft and is held in position by friction. Hard steel pivots are pressed in the ends of the shaft.

The one-piece moulded form on which the *coil* is wound has provisions for attaching the element bridge plate and

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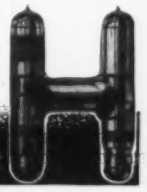

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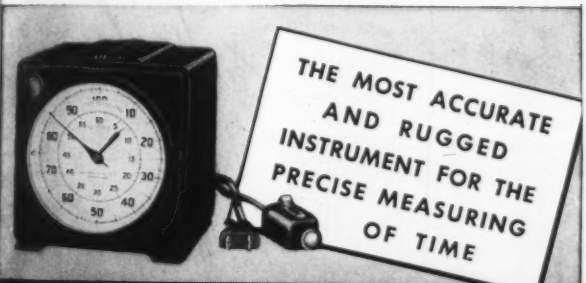

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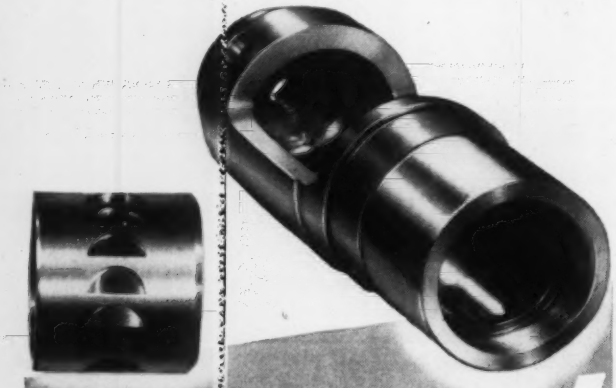

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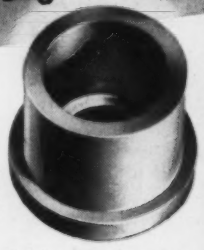

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the *end shields*. The upper and lower *vanes* are welded to the end shields and the shields are attached to the coil form by two screws through each. The holes in the shields through which the mounting screws fit are elongated to allow for movement of the shields in calibrating.

Test and Inspection

The inspection and calibration of these instruments follow the same general method as with all instruments. That is, the instrument is given a mechanical inspection, connected to a test circuit, calibration adjustments effected, scale calibrated, instrument cleaned and cover attached, and final electrical check made for accuracy.

The instrument should be given a rigid mechanical inspection covering balance, end play, connections (soldered and mechanical), friction and general appearance. Springs should be shaped properly, have a clean finish and convolutions should not touch when the pointer is deflected from zero to full scale. The pointer should be straight, of proper length and should be equidistant from the scale at all points. There should be good clearance between all moving and stationary parts. Balance and end play adjustments should be made as outlined in Part I in the discussion of d-c. instruments.

The instrument under test should be connected to a test circuit with a standard of known accuracy. The standard should have a full-scale rating as nearly equal as possible to the full scale of the instrument under test for greatest comparison accuracy.

The response time and damping are adjusted at the factory and should not require further adjustment unless the damping magnet is accidentally demagnetized. The damping factor for these instruments should be between 20 and 100. If the magnet is accidentally weakened, it should be remagnetized or a new one installed.

The calibration adjustments for this type of instrument are: spring, attraction screw and resistance.

While the spring can be used for calibration adjustment of the KA-24 instruments, it is not recommended for field use. Owing to the attraction-repulsion combination characteristics of this instrument, the springs are adjusted and set at the factory for best scale distribution.

The attraction screw adjustment is common to both ammeters and voltmeters. This screw is accessible through the base of the instrument, a small opening being provided to permit the use of a screwdriver for making the adjustment. This hole is sealed when the instrument leaves the factory and can be opened by applying a hot iron to the sealing compound. This screw is located in the approximate center of the base just below the resistance cards of the voltmeter. To adjust the screw of the voltmeter, the resistance cards should be loosened and moved away from the base, or an offset screwdriver may be used. Turning the screw in a clockwise direction increases, and counterclockwise decreases, the deflection of the pointer in the upper part of the scale. This adjustment has no effect on calibration in the lower part of the scale.

The series resistance of the voltmeter is adjusted at the factory in parallel with the capacitors of the instrument. This is to obtain the resonant characteristics necessary to cover the frequency range of the instrument. With this in mind it can readily be seen that any appreciable change of resistance will reduce the frequency range over which the instrument may be used with acceptable accuracy. Therefore, it is recommended that although the series resistance may be used as a calibration adjustment in the field, only minor changes should be made by this method.

Calibration adjustments of the AB-12 instrument shown in Fig. 5 are made by adjusting the spring, and by shifting the upper or lower vanes attached to the cup-shaped shields at the ends of the coil. The shield adjustment changes the relative position of the moving vane to the taper of the upper and lower stationary vanes, effecting a change in the degree of attraction between these vanes. The greatest effect produced by this shield adjustment is between

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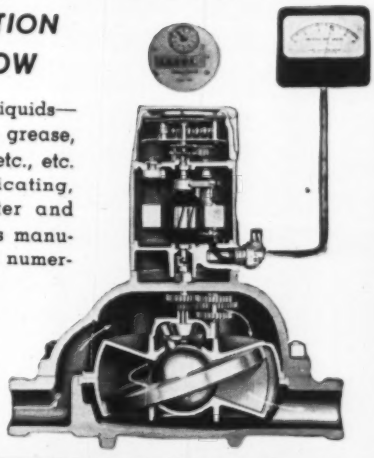

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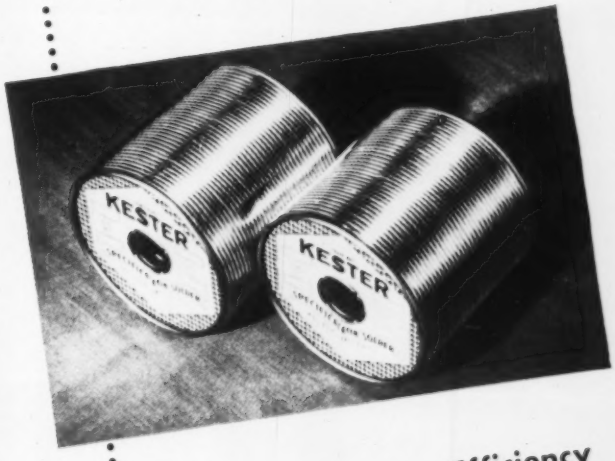

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Thermometer Calibrating Bath

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American Instrument Co.

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70% and full-scale with the scale distribution between 80% and full-scale being affected considerably while the lower scale points are not appreciably changed. *Ascertain that the shield screws are properly tightened before final checking.*

Internal and External Connections

The internal and external connections of the circular scale a-c. ammeters and voltmeters are shown in Fig. 13. Ammeters are connected either in series with the line to

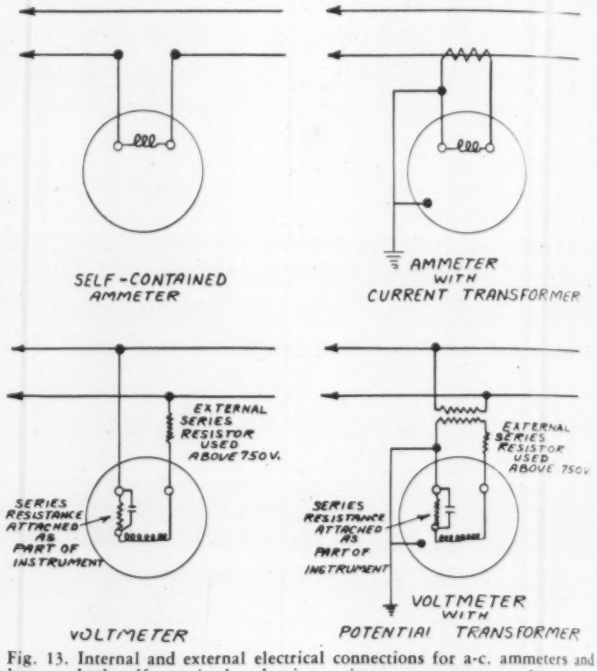
SELF-CONTAINED AMMETER
AMMETER WITH CURRENT TRANSFORMER
EXTERNAL SERIES RESISTOR USED ABOVE 750 V.
SERIES RESISTANCE ATTACHED AS PART OF INSTRUMENT
VOLTMETER
EXTERNAL SERIES RESISTOR USED ABOVE 750V
SERIES RESISTANCE ATTACHED AS PART OF INSTRUMENT
VOLTMETER WITH POTENTIAL TRANSFORMER

Fig. 13. Internal and external electrical connections for a-c. ammeters and voltmeters both self-contained and using resistors or current transformers.

be measured or through an instrument transformer. Voltmeters are connected across the line or across the secondary of a potential transformer. It will be noted that a capacitor is connected across the series resistance of the voltmeter. This is to give the instrument a constant impedance characteristic, increasing the frequency range over which the instrument may be used with good accuracy.

Maintenance

Present-day instruments such as the circular scale type are so designed and made to require a minimum of attention. Owing to misapplication, rough handling and accidents, however, even the best instruments do fail. For this reason, the following information of possible defects is presented.

A few of the possible causes of instrument troubles are friction, open and shorted coil, grounds, hystersis, etc. Friction presents itself more often than any other cause of trouble.

When friction is evident in an instrument, the following conditions should be checked for the defect. Insufficient end play hinders the free movement of the pivoted element shaft in its bearings. Excessive end play causes the element to sag constantly, allowing the element to change its axial position and often touch adjacent parts as it moves. Other points to check when moving parts rub on adjacent parts are alignment and condition (bent or distorted) of pointer, spring, damping vane, and element shaft. A bent pointer may rub on the dial, spring holder, spring, or zero adjuster. A distorted spring could result in convolutions touching, spring touching pointer cross-pieces or tail-piece, or spring rubbing on spring clamp as pointer moves up scale. A bent or distorted damping vane might touch the frame bracket, magnets or bumpers. Should the element assembly shaft be bent, any of the parts of the element assembly might be

Instrument Problem?

Every instrument listed below was originally developed to meet someone's problem—to fill a need. We want to know about *your* instrument problem, no matter how impossible of solution it seems, or how trivial. Our research department is continually seeking for answers to the questions industry asks.

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- **Keeler Polygraph:** (Lie Detector)
- **Phase Sequence Indicator:** 2 models, 115, 230, 460 volts.
- **Soil Resistivity Meter:** 0-30,000 ohms per cubic centimeter.

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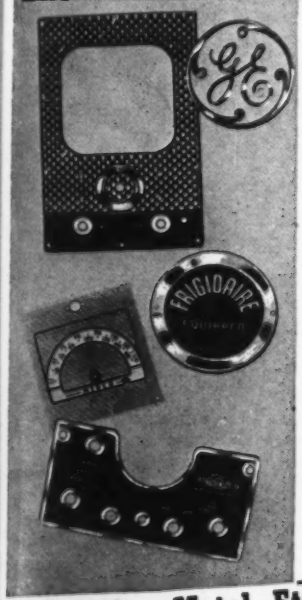

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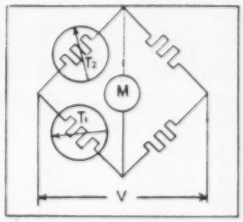
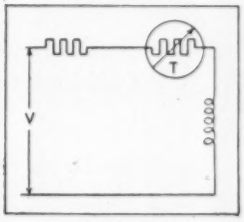
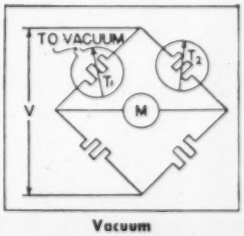


Temperature measuring circuit



Temperature control circuit



Vacuum gage circuit

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MORE APPLICATIONS

G-E THERMISTORS are General Electric's new type thermally sensitive resistors. They are unique in that resistance changes rapidly with slight variations in temperature—electrical resistance *decreases as temperature rises,* and *increases as temperature falls.* Because of their unusual non-ohmic characteristics, G-E THERMISTORS are ideal as circuit control devices.

Perhaps there is an application for G-E THERMISTORS in your product. The three applications shown typify the flexibility of these new circuit devices. They are especially adaptable as the sensitive elements in flow meters, liquid level gages, time delay relays, voltage regulators, vacuum gages, switching devices and other types of indicators or controls.

Why not consult us on your particular problem. For a free technical report, write to *Metallurgy Division, DG-8, Chemical Department, General Electric Company, Pittsfield, Mass.*

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PETROLEUM & CHEMICAL — in the maintenance of pressure-tight systems in petroleum and chemical processing?

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VACUUM TUBES — in the detection of microscopic leaks in vacuum tubes to assure their long and useful life?

HIGH VACUA — in the checking of high-vacuum equipment employed in connection with large-scale plant operations?

PUBLIC UTILITIES — in the location of leaks in municipal gas filled cables and pipe lines, especially those buried underground?

Easy Solution!

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Regardless of the nature of your leak detection problem. Consolidated's Model 24-101A Leak Detector, with its superior speed and accuracy, may well be the ideal solution.

Utilizing the principles of mass spectrometry, with noncontaminating helium gas as the testing material, this instrument combines extreme sensitivity with unusual reliability for the detection and location of leaks in a wide variety of industrial and laboratory equipment.

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so angulated that they would touch adjacent stationary parts.

When instruments are repaired in the field, precautions should be taken to guard against magnetic materials such as iron filings getting in the air gap of the damping magnet. Iron filings and magnetic particles in the magnet air gap cause a drag on the damping vane and hence erratic indications.

The double action bumpers (upper and lower) used in this instrument should be very carefully adjusted after field repairs to prevent pointer sticking. The bumpers should be adjusted so that the pointer first strikes the inside beaded end. The outside bumper should be adjusted to just touch the window of the cover to prevent the pointer from jumping over the bumper on high overloads.

Open circuits in resistors or coils will be evidenced by a lack of pointer indication when the instrument is connected to a live circuit. Before condemning an instrument for open circuit, however, be sure the external circuit (line) is not at fault.

Short circuits in these instruments will give various symptoms, depending upon the part that is affected. A partly shorted coil will result in the instrument indicating too low. The error in reading will depend upon the degree to which the coil is shorted. A completely shorted coil produces little if any field, therefore the instrument will not indicate.

The series resistance of the voltmeter is to increase the range of the instrument. Therefore, any shorting of resistance will decrease the range of the instrument, causing the pointer to indicate too high. A shorted capacitor, by reason of its connections, completely shorts the series resistance lowering the range of the instrument to approximately one-third of its calibrated band. That is, a voltmeter calibrated to a full-scale capacity of 150 volts, will read full-scale at approximately 60 volts if the capacitor is shorted.

As with all instruments using non-residual iron vanes, it should be remembered that any bending of the vanes may change the characteristics. A defective vane, that is, one affected by residual magnetism, will have a tendency to fall out of scale at zero and full-scale, being attracted by the stationary vane or the attraction vane.

SHOP KINK

Piercing Small Uniform Holes *in* Glass

By CHARLES J. CASSIDY, Pittsburgh, Penna.

A CONVENIENT method for piercing reasonably accurate small holes in glass tubes or plates is as follows: A piece of tungsten rod (any desired size, 0.030" to 0.125" dia. is reasonable) is ground to a point on one end. The glass to be pierced is warmed in a soft flame. The pointed end of the tungsten rod is then placed on the spot to be pierced and the tungsten rod heated and rotated in a gas-oxygen flame about ½" away from the glass surface. At the same time, a steady pressure is maintained on the tungsten rod against the glass wall. The heat conducted along the tungsten rod will cause the glass to soften and the rod to slowly force its way through the glass wall. After the puncture is made, the hot tungsten rod is rotated quickly several times in the hole (to shape it uniformly) and is then withdrawn. The small burrs of glass on the inside wall are easily chipped off and the edges glazed with the gas-oxygen torch. After the glass is annealed and cooled, a uniform fairly-accurate hole in the glass wall is the result.

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HAND TOOLS

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If you use hand-tool installation of AMP solderless terminals, be sure every tool has the AMP "Certi-Crimp" feature. Prevents connection failure due to insufficient crimping pressure. Tool handles cannot be re-opened until closed completely for perfect crimp. Guards against operator carelessness or fatigue. Positive, inexpensive, foolproof. Increases convenience of tool. Fully tested in laboratory and actual service. Write for full details. Ask for Catalog Section 30-F.

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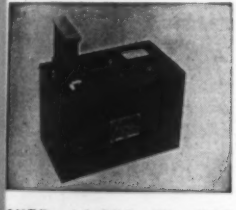

OVER 11,000 IN USE

1. Turn on switch, adjust needle on meter dial.
2. Weigh out an accurate sample.
3. Pour sample into can and take temperature.
4. Pour sample from can immediately into funnel. Trip lever and let sample fall into test cell.
5. Push A, B, C or D buttons progressively until reading is obtained on meter dial.
6. Convert reading on meter dial to actual moisture percentage by means of handy conversion charts, and get final moisture percentage reading.

Steinlite is the most popular electronic moisture tester on the market. Used in elevators, mills, feed processing plants and by many Board of Trade Sampling Departments, and Government Grain Inspection Offices. It operates on the radio frequency impedance principle. Calibrated against official government methods. Sold on a 10-day FREE TRIAL basis.

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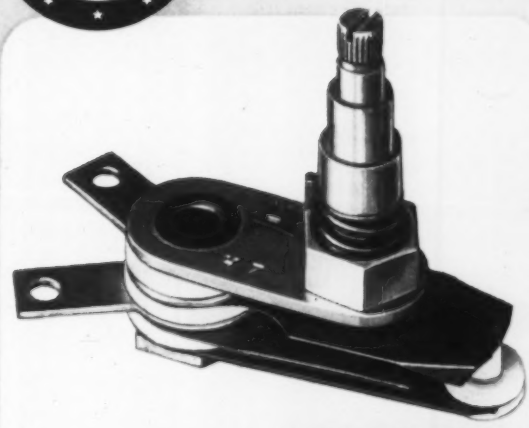

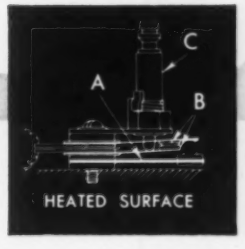

No. 18—A Product of Westinghouse Electric Corporation

The "Uni-Therm" is one of a variety of thermostats manufactured by Westinghouse Electric Company. It represents a typical use of Chace Thermostatic Bimetal in which close control of heat is essential, as in dishwashers, hot plates, ironing machines, irons, etc., from OFF to 550° F. The electrical circuit is entirely insulated from thermal action, as the bimetal element is in direct contact with the heated surface. This shorter heat path makes possible a uniform temperature from no-load to full load. The makers stress six benefits of the "Uni-Therm"—low cost, permanence, compactness, sensitivity, simplicity and accuracy.

As shown in the diagram above, heat causes bimetal element A to bend upward, opening contacts B. Cooling re-establishes contact. Turning stem C moves contacts further from bimetal, thus requiring higher temperature to break current. The design of the actuating element for your own heat responsive device may present similar problems. Why not let Chace engineers suggest a *precise* answer!

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The Month's NEW INSTRUMENTS

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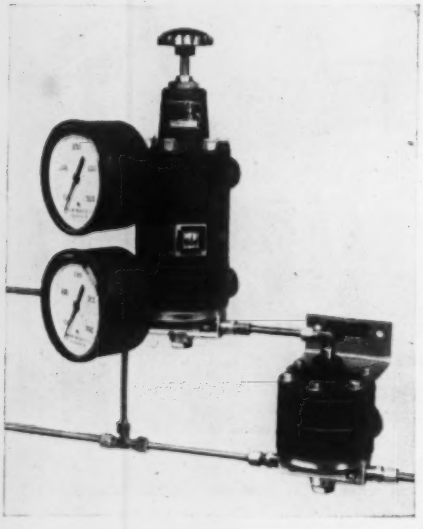
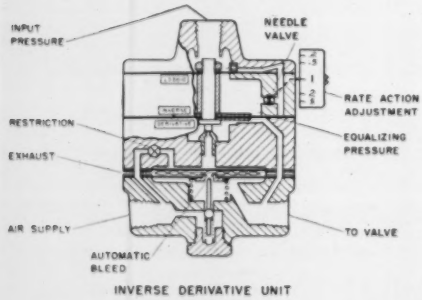
For further information use the Postage-free Order Card on page 775 or the one between pages 762 and 763

Rate Unit for Automatic Controllers

New "Inverse Derivative Unit" for use with maker's "Nullmatic" Controller operates, like the controller, on the



pneumatic force-balance system. Its purpose is to superimpose a type of rate action, which maker terms an "inverse derivative," on output of controller. Announcement explains that new unit is designed for applications in which reaction time through process is faster than correction time through control



INVERSE DERIVATIVE UNIT

valve: flow, pressure, and liquid-level control applications which have small capacities, would generally come in this category. Processes which involve long time lags, notably temperature applications, are benefited by adding a "direct" derivative function: control valve can move much faster than process can change, and derivative action serves to give "anticipatory" control. Direct derivative action temporarily narrows proportional band; inverse derivative action temporarily widens proportional band. Announcement states further that in a fast-acting process, direct derivative will generally serve to amplify tendency to cycle, because control valve cannot be made to move as fast as process. With inverse derivative, narrower proportional band settings are possible. It is claimed that the instant the process tends to become unstable, or to go into a cycle, "Inverse Derivative Unit" acts to temporarily widen the proportional band, which action restores stability to the process. According to test results, new unit permits a reduction of proportional band setting on the controller to less than 1/5 of normal value. —*Moore Products Co., H & Lycoming Sts., Philadelphia 24, Pa.*

Please mention number **801** when filling out card

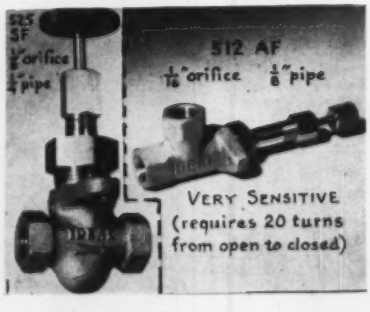
Thermometric Bridge

New bridge provides a moderately-priced instrument for use with maker's resistance thermometer bulbs (described in *Instruments*, May, 1948, page 417). Bridge has built-in galvanometer, four dials and slide-wire adjustment which permits calibration for small differences in the ice-point resistance of the bulbs. Range is 999.9 ohms and accuracy of 0.1% is claimed. Bridge permits reading temperatures with accuracy of 0.3°C. (temperature differences much closer). Temperature measurements up to 1,000°C. are possible with bulbs of 200-ohm resistance.—*Paul G. Weiller, 95 Broad St., New York 4, N. Y.*

Please mention number **802** when filling out card

Needle Valves

Six new series of needle valves are announced, four models in each series (24 new models), in pipe sizes from



⅛" to ½". Originally designed for use in maker's own aircraft-instrument testing apparatus, they will find many uses in instrument work, in research laboratories, etc. Stainless-steel needles are available at extra cost. Highest precision machining is claimed, giving reproducibility of settings.—*Ideal Laboratory Tool & Supply Co., 3619 Evans Ave., Cheyenne, Wyoming.*

Please mention number **803** when filling out card

Ultrasonic-method Thickness Gage and Flaw Detector

New "Metroscope" is an ultrasonic device which measures the wall thickness of metal, plastic and glass parts

where only one surface is accessible; and which also makes rapid, non-destructive tests to detect flaws and imperfections in these materials. It measures wall thickness of a long tube with less than 2% error, and detects thin voids and cracks that do not appear in an x-ray. It employs an oscillator to generate voltage, the frequency of which is varied until the part resonates. Since resonant-frequency and thickness are related for any given material, it is possible to calibrate to read thicknesses of tubes and flat parts between 0.015" and 0.0300". Steel, brass, nickel, copper, silver, aluminum, magnesium, lead, glass and plastic, may be measured and tested.—*Photocon Research Products, 1062 North Allen Ave., Pasadena 7, Calif.*

Please mention number **804** when filling out card

Pocket-size FM Generator

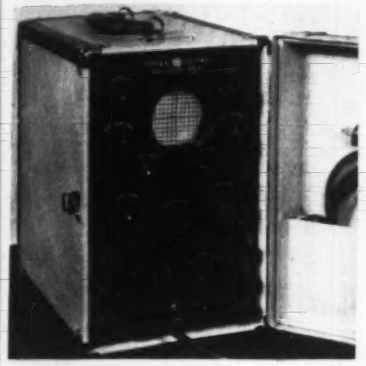
New "Model 720 Frequency Modulated Signal Generator" is said to provide accuracy and stability in a minia-

ure, practical unit. It has continuously aluable attenuator and compactness s achieved by using only the four fre- uencies actually needed in FM servic- ng or alignment. These are 10.7 Mc. or i.f. and 88 Mc. for low end; 98 Mc or midpoint and 108 Mc. for top end of FM band. May be operated from a-c. or d-c. lines, 95 to 130 volts. Case dimensions 3" × 6" × 2¾", weight 2 lbs.—*Radio City Products Co., Inc., 152 West 25th St., New York 1, N. Y.*

Please mention number **805** when filling out card

Industrial C-r. Oscilloscope

New "Type YNA-4 Industrial Oscil- loscope" was designed specifically for servicing resistance welders, motor con-

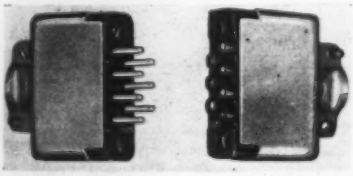


trol circuits, power supplies, photo- electric circuits, etc. Scope has a 3" tube with sufficient sensitivity to ex- pand trace to several times tube size. Equipment features push-pull d-c. am- plifiers of high sensitivity, high and low impedance vertical input with step and continuous attenuation to handle wide range of signal input, horizontal sweep range 10 cycles per second to 20 kc./sec., internal source of d.c. for de- flection calibration, and completely in- sulated case and panel permitting oper- ation up to 550 volts above ground. Device weighs about 25 lbs.—*Specialty Div., General Electric Co., Syracuse, N. Y.*

Please mention number **806** when filling out card

Aircraft Connector

New seven-contact lightweight air- craft connector has melamine molded parts with telescopic barriers to pro-



vide long creepage paths. Contacts are precision machined and silver-plated. Breakdown voltage between contacts, 2500 d.c. or 5300 a.c. Creepage between contacts 7/32" min. Air space between contacts 3/32" min.—*Winchester Elec- tronics Co., 6 East 46th St., New York 17, N. Y.*

Please mention number **807** when filling out card

Precision Aneroid Barometers

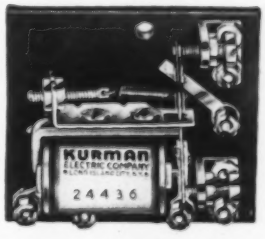
New models of maker's precision an- eroid barometers are announced. Pres- ent line covers any range of absolute

pressure from one-tenth of an atmos- phere (3" of mercury) to a full atmos- phere. Each barometer is individually calibrated and has a custom-drawn scale. Barometers may be made to or- der for specific ranges in any desired pressure equivalent. Models are avail- able for wall mounting, panel mount- ing, desk mounting and portable use.—*Wallace & Tiernan Products, Inc., 1 Main Street, Belleville 9, N. J.*

Please mention number **808** when filling out card

A-c. and D-c. Relay

New "24" relay, with split armature, is for automatic controls, keying, an- tenna changeover, burglar alarms and closed-circuit applications. Rated sensi-

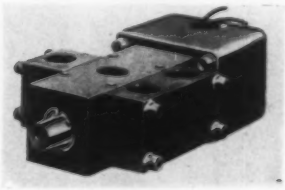


tivity is 0.014 watts d.c. and a.c. and 0.3 va., a.c. Adjusts to operate at 0.005 watts and from 0.01 to 115 volts d.c. or a.c. New model is said to incorporate contact flexibility, u-shaped magnetic circuit of high permeability.—*Kurman Electric Co., 35-18 37th St., Long Is- land City 1, N. Y.*

Please mention number **809** when filling out card

Solenoid-operated 4-way Valves

New "8900" line of a.-c. solenoid oper- ated 4-way selector valves is designed for service with water, oil or air at operating pressures to 250 lbs./in.². Includes pipe sizes from ¼" to 1". Valves may be converted for d-c. oper- ation merely by changing solenoids. Features are (1) leak-proof, "shear-

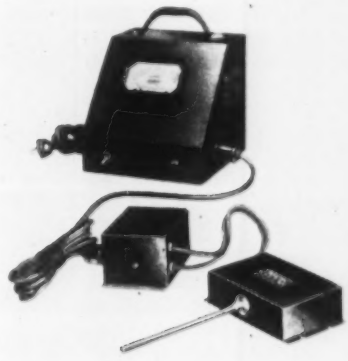


seal" design; (2) only one moving part; (3) direct operation, eliminating hazards of pilot operation; (4) fast, positive action; (5) ease of installa- tion. Constant metal-to-metal contact of sealing members wipes away foreign material; hence, valve is not critical to dirt. Valve is two-position-spring-load- ed in normal position. Measures $7\frac{13}{16}$" × $5\frac{1}{4}$" × $3\frac{1}{2}$".—*Saval, Inc., 1915 East 51st St., Los Angeles 11, Calif.*

Please mention number **810** when filling out card

Indicating Vacuum Gage

New "Televac 500 Thermal Gage" for measuring vacua within range of 0-1000 microns is continuously-indicat- ing type instrument. Calibration is un-



affected by contaminating vapors in vacuum system. Indicating scale is cali- brated directly in microns. A voltage stabilizer mounted within case elimi- nates errors due to line voltage fluctua- tions. No current adjustments or cali- bration of gage is necessary before readings. Simplicity of operation and stable calibration are said to make in- strument ideal for refrigeration indus- try, dehydration, distillation, vacuum tube manufacture, etc. Gages are avail- able in either Pyrex glass or metal to withstand 50 lbs./in.².—*George E. Fredericks Co., Bethayres, Penna.*

Please mention number **811** when filling out card

Hole-inspection Light

New deep hole inspection light makes it possible to see clearly into drilled holes, tapped holes, interior cavities of castings, tubing and other interiors re-

quiring close inspection. Device is held by operator about 5" from end of hole. Operator then sights at hole through diam., 1"; Underwriters' listed seal is an angle lens. His line of vision passes through lens into hole surrounded by a

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Servograph

POSITION RECORDER

A new type graphic recorder which operates from a remote point WITH NO MECHANICAL LINKAGE.

the heart of the servograph--->

is an extremely accurate variable ratio device making the SERVOGRAPH so flexible that a single adjustment provides full chart coverage within a range of ½ to 15 revolutions.

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INCORPORATED

Manufacturing Division

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cylinder of light reflected from a 6-volt lamp. New light is made in two convenient forms: Portable type for chief inspectors and bench design for multiple inspection work.—*Extractor Corp., 25741 W. Seven Mile Rd., Detroit 19, Mich.*

Please mention number **812** when filling out card

Pocket Microscope

New "Magnicon" is a portable compound microscope with powers from 20× to 60×; is 5¼" long when closed;

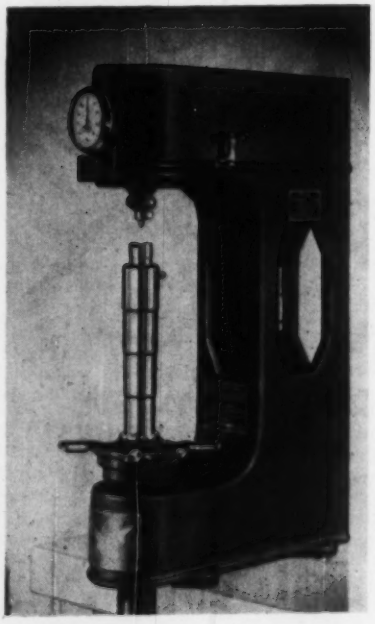
weighs 3 oz. Makers state that it permits direct examination of opaque surfaces and eliminates use of slides as well as cutting or fixing prior to examination. It requires only ordinary daylight or artificial light.—*Optical Development Corp., 5 Beekman Street, New York 7, N. Y.*

Please mention number **813** when filling out card

Hardness Tester

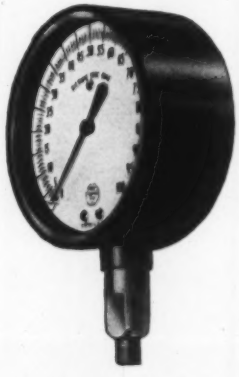
New Superficial Hardness Tester for Rockwell testing is designed for testing surfaces that must not be marred, even by standard Rockwell indentation. Depth of penetration with new tester is held to limits of 0.005" or less. Particularly suitable for testing surface-hardened steel, except[ionally] thin metals, rolled sheet metal, [or very] small areas. Available in three [models,] with 8", 12", or 16" vertical [capacity.] Furnished are diamond cone [penetra-]tor, 1/16" steel ball penetrat[or, and] test blocks.—*Clark Instrume[nt Inc.,] 10200 Ford Rd., Dearborn, Mi[ch.]*

Please mention number **814** when filling [out card]



Vapor-test-bomb Gage

New Standard Test Gage for use with Reid Vapor Test bombs may also be used for any service where accurate,

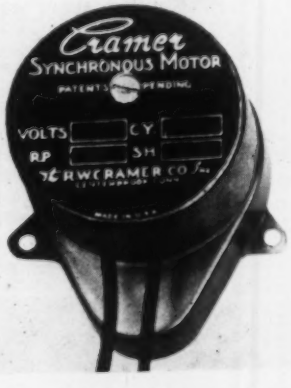


portable test gage is required. Accuracy is guaranteed within 0.5%. Dial size is 4½". Flangeless case is weatherproof with an external micrometer pointer adjuster. Shank has square ¼" male pipe thread.—*Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.*

Please mention number **815** when filling out card

Synchronous Motor

New "Type SX" self-starting synchronous motor has been redesigned to make motor assembly (without gear



train) completely self-contained. It is designed for use with timing devices, recording and communications equipment and other applications requiring constant speed at a given frequency. Motor reaches synchronous speed within ½ to 2 cycles and will stop within one pole of motion on the 240 r.p.m. rotor shaft (¼ sec.) when de-energized. Clockwise or counterclockwise motors can be supplied. Motor is 2⅜" × 2⅛" × 1½". Standard gear trains, ranging in speeds from 60 r.p.m. to one revolution in 24 hours are available. One-way

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That's all it takes! Four basic circuits and 8 basic component parts give you more than 100,000 different electronic instrument combinations for processing use.

Flow, level, speed, pressure, temperature, gas analysis, pH, conductivity, etc.—all can be controlled with these interchangeable Bailey units.

With Bailey controls, replacement part stocks are held to a minimum because parts are interchangeable. Maintenance costs are less, too, because maintenance men quickly become familiar with the standardized Bailey units.

Bailey bulletin No. 17 shows how you can use this improved control system. Write for your copy and keep it handy for reference the next time you need process controls.

P-19

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TEMPERATURE • FLOW • PRESSURE
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Electrical Instrument Makers
extends a cordial invitation
to examine a representative group
of its instruments at the
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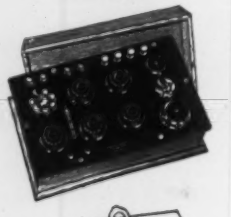
THE PORTABLE PRECISION POTENTIOMETER
. . . a two-dial instrument complete with built-in standard cell, battery and galvanometer, ready for instant service.
- High precision
- Wide selection of ranges
- Sensitivity to within 2 microvolts
- Sturdy, self-contained, compact

Described with other Rubicon potentiometers in Bulletin 270.

THE SPOTLIGHT GALVANOMETER
. . . a rugged, taut-suspension galvanometer with self-contained multiple-reflection lamp-and-scale optical system . . . sensitivities from 1.5μV per mm. to 0.0006μA per mm . . . . used extensively for both null and deflection measurements in research and routine control laboratories.
Fully described in Bulletin 320.

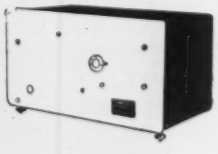


THE MUELLER BRIDGE
A highly accurate instrument for precise resistance thermometry. Distinctive features include:
- Wide range: 0 to 71.1110 ohms in steps of 0.0001 ohm.
- Built-in mercury-contact commutator for normal and reverse readings to eliminate effect of resistance variation in leads to thermometer.
- Built-in plug and block assembly for conveniently checking ratio value and determining bridge zero and thermometer resistance.
- Subpanel switch construction.

Described with other bridges and standard resistors in Bulletin 100.

THE PORTABLE WHEATSTONE BRIDGE
A self-contained instrument combining moderate precision with instant portability for general use in laboratory, plant or field.
- Wide range: 1 ohm to 10 megohms.
- Limit of error: 0.1%
- Built-in battery and galvanometer.
- Provision for external battery and galvanometer when required.
- Available with Murray and Varley loop circuits.
- Compact and rugged.

Described with other bridges and standard resistors in Bulletin 100.



THE PHOTOELECTRIC GALVANOMETER
A short-period taut-suspension galvanometer of completely new design with built-in double-cathode phototube and balanced twin amplifier for three major uses:
- Indication of null balance to within 0.01μV with effective period of 0.6 second.
- Automatic control with reliable operation on ± 0.1μV
- Automatic low-level recording with full-scale ranges down to 10μV or less.

Described with other galvanometers in Bulletin 320.

RECORDING AUTOMATIC H_2S and NO ANALYZERS
Automatic photometric analyzers of high specificity and sensitivity . . . full-scale ranges down to approximately 1 PPM available . . . readily equipped with alarm or control switch actuated when concentration exceeds a preselected limit.
Descriptive literature on request.

OTHER RUBICON INSTRUMENTS
Evelyn Photoelectric Colorimeter for precise chemical analysis • Precision Potentiometers • Kelvin Bridges • Standard Resistors and Resistance Boxes • Magnetic Permeameters • Shorted-Turn Coil Testers • Magnetic Hardness Testers • Magnetometers for intercomparing permanent magnets • Special equipment involving precise measurement or control of electrical quantities.

RUBICON COMPANY
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friction is available for applications where driven mechanism must not be turned backwards. Easily-removable coils facilitate changes in voltage rating or field servicing.—*The R. W. Cramer Co., Inc., Centerbrook, Conn.*

Please mention number **816** when filling out card

Illuminated Magnifier

New "Supersite" magnifier for general industrial and commercial use is designed with an 8″ lens. 12″ fluo-

rescent lamp, which circles lens, provides even and full illumination without shadow at every point directly under lens. Both table and floor models are available.—*The Safety Center, 542 S. Dearborn St., Chicago 5, Ill.*

Please mention number **817** when filling out card

Granite Straight-edge

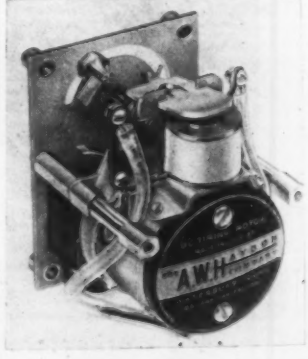
New Granite Straight-edge is said to have an accuracy of 0.0001″ every 3 ft. Non-warping quality obviates need of

continual rechecking. Approximately same weight as conventional cast iron straight-edge. Sizes available up to 6 ft. Equipped with handles.—*Herman Stone Co., 324 Harries Bldg., Dayton 2, Ohio.*

Please mention number **818** when filling out card

Time-delay Relays

New "Series 11400 A.c." and "6400 D.c." time relays have planetary differential and "capstan" type clutch mech-



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INSTRUMENT AIR DRYERS

used in large Eastern Chemical Plant

Standard off the shelf *Silica Gel DEHYDRAIRE units which insure clean and dry air—free of oil and water vapor.

DEHYDRAIRES with capacities of 12½ to 1000 CFM (STP) at 100 PSIG and 70°F will dry the air for 25 to 2000 air operated instruments. The air leaving DEHYDRAIRES will have a final dew point as low as –60°F assuring absolute dryness regardless of coldest temperatures to which lines may be exposed.

Models for either single or polyphase electric reactivation or steam reactivation where steam pressures of 100 lbs. or over are available.

DEHYDRAIRE Units will be exhibited at the Third Annual Instrument Conference and Exhibit, Booth 247, Convention Hall, Philadelphia.

Write for full description, prices, etc., to Sales Engineering Department

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For Precision *plus* Economy

For pressures and vacuums . . . with ranges from water inches up to 30,000 P. S. I. . . . . there's an ACRAGAGE scientifically designed to give you dependable precision on steam, oil, gas, chemicals, water, or brine. ACRAGAGE comes in a wide variety of sizes — 4½", 6", 8½", or 10", with wall, stem, or true flush mountings. ACRAGAGE cuts down your operating expense . . . protects you against costly errors and inaccuracies.

20% to 30% Longer *Bourdon* Tubes

Bourdon tubes in the ACRAGAGE are 20% to 30% longer than average . . . resulting in the following advantages: less strain per unit length on the spring; increased durability; longer fatigue life; heavier wall thickness for added safety; greater tip-travel — providing sustained accuracies to within one-half of one percent!

Remember ACRAGAGE — a quality product made by skilled craftsmen from materials which meet rigid standards, including Army and Navy specifications.

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CLAPP INSTRUMENT CO.

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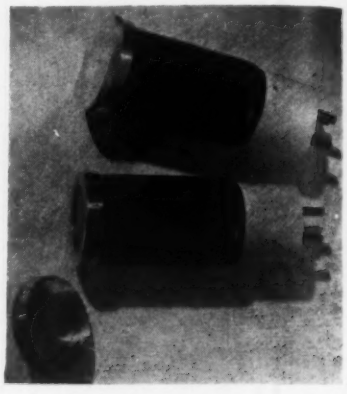
WEBSTER, MASS.

anism which drive switch-a tuati arm when clutch holds third eleme of differential stationary. Mechanic amplification of forces obtained "capstan" clutch allows use of sma electromagnet, thus minimizing ope ating current and size of unit. "A most any" time-delay interval is said be possible.—*A. W. Haydon, Waterbu Conn.*

Please mention number 819 when filling out card

End-window-type G-M Tubes

New "Type TGC-1" tube has a mic window 3-4 mg./cm.^{2} and "Type TG 2" tube (more sensitive) has a mic

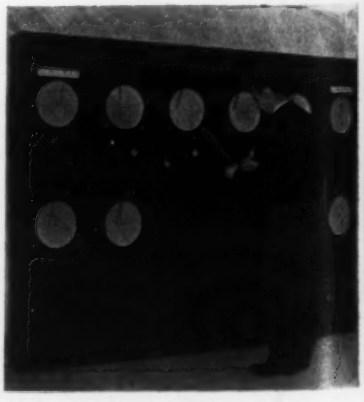


window less than 2 mg./cm.^{2}; the la ter is especially for determination low-energy emitters such as carbon and sulphur 35. Useful life 10^8 counts Extremely long flat plateau in excess 300 volts permits reproducible results Each tube furnished with starting volt age and position and length of oper ating plateau. — *Tracerlab, 55 Olive St., Boston 10, Mass.*

Please mention number 820 when filling out card

Standard-size-section Panel Boards

New standard-size sectional ste panel boards are fabricated to contai any type of control or indicating in strument. Constructed of 10-gage ste panels provide rigid support fo precision-instrument operation. Versa tility is offered because once standar sections have been erected, additiona sections can be added, sections can b interchanged or removed, or otherwis modified to meet changing plant oper ating conditions. Standard 18", 20

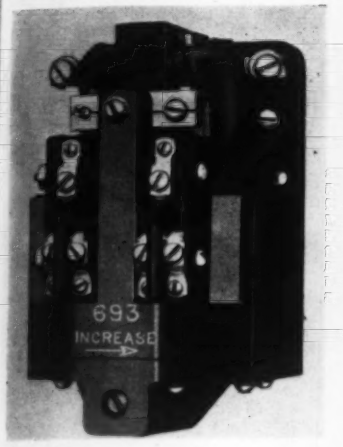


d 24" wide sections are supplied in 6½-, 7-, 7½- and 8-ft. heights. Each ch panel has 2" minimum return nge on top and bottom as well as on ch side. Floor or wall braces are fur- hed. Panels supplied in any specified or.—*K & H Industrial Products, pt. 23, Akron 11, Ohio.*

Please mention number **821** when filling out card

Pneumatic Timer

New a-c. pneumatic timer is designed r controlling timing of machine tools, nveyors, automatic processing equip-

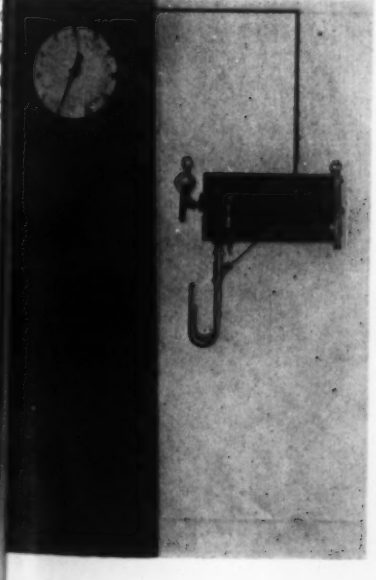


ent, etc. Timer is 2¾" wide by 4⅞" gh. Eight turns of a screw give en- e timing range from 0.3 second to minutes. Reset is practically instan- neous. Timer is available either with e or two independently-adjustable ming steps—the two steps eliminate e need of one timing relay.—*Cutler-mmer, Inc., 256 North 12th St., Mil-aukee 1, Wis.*

Please mention number **822** when filling out card

Flue-gas Analyzer

New flue-gas analyzer continuously dicates and records stack gases as a ide to more efficient combustion; alyzes composite of stack gases and es continuous indication of com- eteness of combustion — indicating



FOR HIGH-SPEED, SENSITIVE RECORDINGS

Photoelectric Recorder..

WAS SELECTED BY MINNESOTA MINING & MANUFACTURING CO.

The Minnesota Mining and Manufacturing Company is using a General Electric Photoelectric Recorder in preliminary studies of new machine designs. Here, it is being used for recording oil pressure in evaluating the application of an automatic, variable-speed, hydraulic drive to process equipment. As a result of this study, several changes were made on the oil drive which enhanced its performance and life expectancy in the particular application.

G-E High-speed Photoelectric Recorder

The Minnesota Mining and Manufacturing Co., is just one of the many users who have found the G-E Photoelectric Recorder useful in solving their problems. It is also used for thermocouple response tests, resistance thermometry, and general physiological research. In fact, its extreme sensitivity and high-speed response make it ideally suited to many other applications embracing the entire field of measurements. It can RECORD ANYTHING THAT CAN BE MEASURED by an indicating instrument.

A wide range of sensitivities (which go as low as 1.0 microamperes for full-scale deflection) and response speeds (as high as ¼ second) are available in the photoelectric recorder. Basic elements are interchangeable so that one instrument can cover a number of ranges. It is also available as a potentiometer recorder. Write for Bulletin GEA-2394, or contact your nearest G-E Sales Office and let us help you with your application problems. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

402-124

In hundreds of installations, SPRINGLESS CONOMOTORS are daily proving themselves unequalled for heavy duty control services.

Wherever POSITIVE POSITION and POWER are requisites, SPRINGLESS CONOMOTORS do the job better. You will find them operating heavy louvers and dampers in air conditioning installations, big chopper valves on fluid catalytic cracking units, variable speed drives on processing machinery and in numerous other applications in pilot plants, steel plants, and similar industrial plants using pneumatic control instruments.

SPRINGLESS CONOMOTORS are twenty to thirty times more powerful than the ordinary Spring and Diaphragm Motors. They can be adjusted to suit the type, direction, and magnitude of the load. No usless work is done in compressing springs. Every ounce of power is available for doing external work. Write for Bulletin B-1222.

CONOFLOW CORPORATION, 2100 ARCH ST., PHILA. 3, PA.

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any deviation from ideal c[onditions]. Analyzer consists of a reco[rder] panel 2 ft. wide × 6½ ft. [high] maker's "Flow Panel" to be [mounte] near or at point of sampl[ing]. It electrically operated from 11[0-volt] cycle a.c. A Wheatstone bridge [a]stainless steel analysis cell measu[re] the thermal conductivity of [composit] stack gases. A newly-designed, simpl[i]fied flow scheme utilizes differenti[al] pressure in stack to cause an amp[le] continuous flow of stack gases throug[h] analysis cell. — *Davis Emergen[cy] Equipment Co., Instrument Divisio[n], 45 Halleck St., Newark 4, N. J.*

Please mention number 823 when filling out card

End-Window Geiger Counter

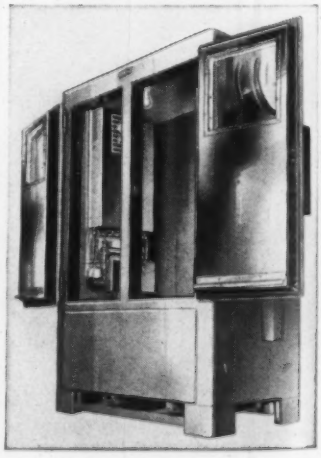
New "Model D31 End-Window Gei[ger] Tube" is for use on upright or soc[ket] et sample holder. Counter has all-gla[ss]

envelope with mica window. Standar[d] window thickness is two to four mill[i]grams per square centimeter. Platea[u] from 1100 to 1300 volts, with a slop[e] of 3% per hundred volts. Life is guar[an]teed at 10^8 counts without quenc[h] circuit.—*Instrument Development La[b]oratories, 229 West Erie St., Chica[go] 10, Ill.*

Please mention number 824 when filling out card

Controlled-humidity Chamber

New humidity simulation unit pr[o]duces and maintains atmospheric hu[mi]midity conditions ranging from 20% t[o] 95% between 35°F. and 175°F. (dr[y] bulb). Available in four cabinet size[s] from 10 to 35 cu. ft. capacities. Cab[i]nets recommended for tests of radi[o]



capacitors, paints, paper containers, oil, seed germination, bakers' dough, adhesive tapes and other drug, food and industrial products. All models operate on 110-volt 60-cycle single-phase a.c. Wet-bulb control and humidity reservoir water level are maintained by float valves. Air movers provide circulation within stainless-steel test space.—*Bowser, Inc., Terryville, Conn.*

Please mention number 825 when filling out card

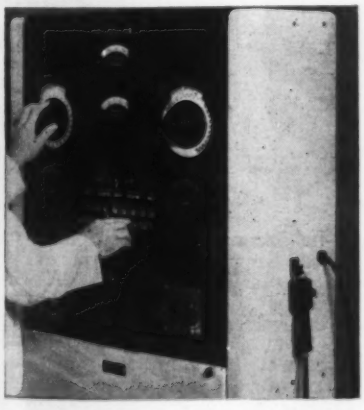
Carbon Dioxide Indicator

New "Model 600" carbon dioxide indicator, suitable for testing efficiency of oil burners, furnaces, and other heating plants is constructed of transparent acrylic material and practically unbreakable, with metal parts of non-corroding stainless steel. Pressure-tight "O" rings are used as seals. Indicator is 8" long and 2" in diameter. Capable of making three tests a minute, it has a 4" scale calibrated to 0.2% CO_2. Accuracy is stated to be 0.5% CO_2.—*F. W. Dwyer Mfg. Co., 317 South Western Ave., Chicago 12, Ill.*

Please mention number 826 when filling out card

Control Cabinet for X-ray Equipment

New "Centralinear" vertical control for 200-ma. x-ray equipment has a "Mechanical-Brain" milliamperage selector said to reduce by 50% the number of movements required to make a radiographic exposure. It may be adapted to radiography, fluoroscopy, superficial therapy, spot-film radiography and photo-roentgenography (including angiocardiography). The technician is



Now Electrical Impulse Recording is

Instantaneous!

Yes, Brush oscillographs draw *instant* pictures of electrical impulses. Eliminate delays and trouble when you want accurate, permanent, ink-on-paper recordings.

Recordings of strains, pressures and countless electrical phenomena can be made over a frequency range of D.C. to 100 c.p.s. Today Brush Oscillographs are available in Single, Double and Six Channel models. The magnetic Pen Motor is available separately for incorporation into equipment such as medical, geophysical and other highly specialized designs. Whenever desired, recordings may be stopped for notations on chart-paper.

Brush Model BL-913 D.C. Amplifier. Well adapted to the measurement of static or dynamic phenomena such as temperature, light, pressures, strains, etc.

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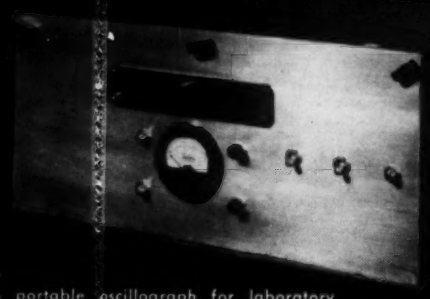
Canadian Representatives: A. C. Wickman (Canada) Ltd. P. O. Box 9, Station N, Toronto 14

Century

PORTABLE OSCILLOGRAPH



A portable oscillograph for laboratory or field use; this instrument incorporates high standards of accuracy with rugged dependability.

Available with banks of from four to twenty-five hermetrically sealed, pencil-type Century galvanometers in a wide selection of frequencies and sensitivities, this instrument faithfully reproduces on positive recording film bearing simultaneously superimposed timing lines.

Paper widths from 35 mm to 6 inches and a wide range of synchronous motor and tuning fork components are available for operation from 110 volts in the laboratory or for 12-24 volts d.c. truck or aircraft operation. Completely portable daylight developing equipment obtainable if required.

A letter of inquiry regarding the application of this instrument to your needs will receive the prompt attention of our engineers.

ANOTHER Century PRODUCT

CENTURY GEOPHYSICAL CORP.

TULSA, OKLAHOMA

NEW YORK
149 Broadway

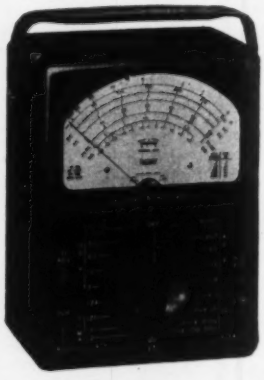
HOUSTON
Niels-Esperson Building

said to be relieved of selecting the proper tube and desired focal spot, setting the ma. value, choosing milliammeter scale, and connecting timer.—*General Electric X-Ray Corp., 4855 West McGeoch Ave., Milwaukee 14, Wis.*

Please mention number **827** when filling out card

Volt-ohm-milliammeter

New "Model 630 Volt-Ohm-Mil-Ammeter" is said to be of advanced modernistic design. A new type enclosed

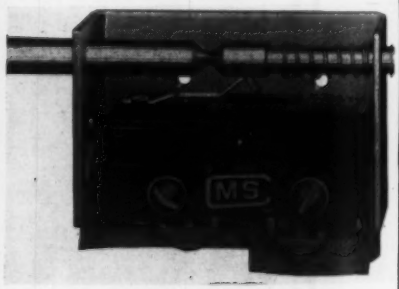


molded switch permanently retains contact alignment. Resistors are precision grade. Six d-c. volt ranges from 0 to 6000, at 20,000 ohms/volt assure greater accuracy for testing television and other high-resistance d-c. and a-c. circuits. Six a-c. ranges to 6000, at 5000 ohms/volt provide greater accuracy in audio and other high-impedance a-c. circuits. Five direct-current ranges from 0-60 microamperes to 0-12 amps; resistance ranges to 100 megohms; decibel from −30 to +70 db and output ranges afford complete analysis. Indicator has 5½" easy-to-read multicolor scales. Black molded case, $3\frac{7}{32}$" × 5½" × 7½", is completely insulated and has removable leather handle.—*Triplett Electric Instrument Co., Bluffton, Ohio.*

Please mention number **828** when filling out card

Door Switch

New "Interlock Door Switch" is for use on high-frequency radio, radar, x-ray and television equipment cabi-

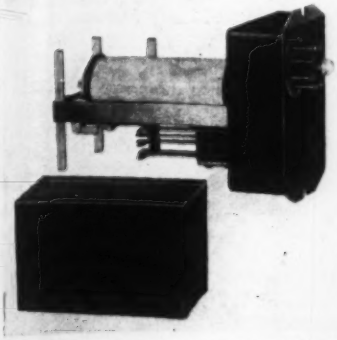


nets, induction heating equipment and electronic controls. Switch assures safety as it cuts off power circuit when cabinet door is opened. Switching element is basic leaf actuator design, listed at 10 amps, 125 volts a.c.; 5 amps 250 volts a.c.; 3 amps 460 volts a.c.—*Micro Switch, Freeport, Illinois.*

Please mention number **829** when filling out card

Plug-in Relay

New dust-tight plug-in relay base and cover is for use where dust may affect operation of unprotected relays. Assembly consists of an a-c. or d-c.



relay mounted on a dust-tight base, terminals brought through a Neoprene gasket. Steel cover can be readily removed for inspection of relay. Either a radio-type plug or a 15-point plug of different design complete the installation.—*C. P. Clare & Co., 4719 West Sunnyside Ave., Chicago 30, Ill.*

Please mention number 830 when filling out card

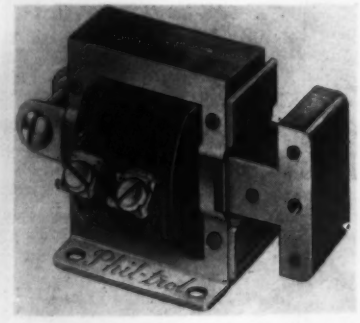
Aircraft Trim-tab Control Switch

New "Style TC-58-W" master switch is said to provide centralized fingertip control for the entire trim-tab system of an airplane. Two conveniently placed levers actuate six different switches governing the forward and reverse fields of three electrical thrust motors which operate aileron, elevator, and rudder trim tabs. Lever arrangement is such that it is impossible to operate both elevator and aileron tab motors at same time. Snap-action switches are capable of handling a ten-ampere non-inductive load at 24 volts d.c. Entire control unit is contained in steel housing 3 11/16" deep × 3 7/16" × 3½"; operating levers extend ¾" out of panel housing.—*General Control Co., 1200 Soldiers Field Road, Boston, Mass.*

Please mention number 831 when filling out card

1"-stroke Power Unit

New "51A Actuator" is a solenoid type power unit featuring a frame of firmly bonded silicon steel laminations



and a T-shaped laminated plunger adaptable for both push and pull operations. Available for continuous duty on 115-volt 60-cycle supply with a maximum stroke of 1". Approximate pull: 2 lbs. at ¾" stroke; 3.4 lbs. at ½"; 4.2 lbs. at ¼"; over 17 lbs. sealed. The "51A" can be wound for other a.-c.

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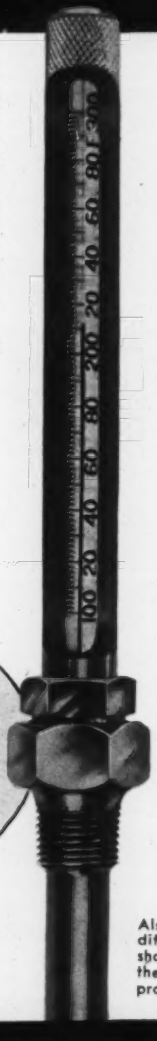
With Separable Socket



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Bulb Chamber, which is removable with Armor for easy access to damaged stem and removal of broken section.

Separable socket which remains as seal in equipment, permitting its uninterrupted operation and production.

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voltages or to provide more pull where duty cycle is intermittent. Shading rings and precision ground pole faces insure quiet operation. Over-all dimensions, 3½" long by 1⅞" wide by 1 15/16" high.—*Phillips Control Corp., 612 N. Michigan Ave., Chicago 11, Ill.*

Please mention number 832 when filling out card

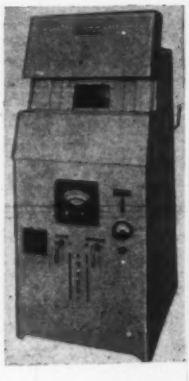
40-to-220-Mc.-range Transformer

New "Model M-286" transformer was designed for matching 72-ohm co-axial to 300-ohm balanced line in the range from 40 to 220 Mc. While developed for use with maker's "Model 80 Standard Signal Generator in conjunction with 72-ohm matching pad, new transformer is adaptable to signal generators in its frequency range and may also be used for matching co-axial 72-ohm lines to receivers having an input impedance of 300 ohms. Transformer yields voltage step-up of 1:2. Transformer has coaxial fitting and soldering lugs are provided for connections to 300 ohm termination. —*Measurements Corp., Boonton, N. J.*

Please mention number 833 when filling out card

Box-Type Furnace

New "Model G-10" box-type laboratory furnace provides temperatures up to 3000°F. for continuous operation as high as 2500°F. Self-contained unit may also be used as muffle furnace, or with carbon blocks for non-oxidizing atmospheres. Ten silicon carbide "Globar" heating elements are said to insure uniform heating. Furnace temperatures are regulated by indicating-controlling pyrometer. "Model G-10" is for operation on 230 volts, 60 cycle, single phase a.c. Variable voltage transformer has capacity of 8 kw. and has six control points for voltage regulation.—*Lindberg Engineering Co., 2444 W. Hubbard St., Chicago 12, Ill.*



Please mention number 834 when filling out card

Electric Tachometer

New "Electric Panel Type Tachometer" for continuous speed measurements consists of a pick-up generator with a stationary armature and a small Alnico magnet rotor mounted on sealed ball bearings. There are no brushes or other wearing parts. A rectifier type instrument with a d'Arsonval movement can be furnished in either 3" or 7" size and is regularly furnished in 0-1250, 0-2500 and 0-5000 rpm. ranges

an also be furnished with suitable calibration to give fpm., gpm., etc. Tachometer has an accuracy of ± 1%. Diameter of generator is 1⅝" and, with mounting bracket, overall height is 2½". Length including shaft extension and electrical plug is 4½". Instrument may be located as far as 200 feet from generator.—*Crown Industrial Products Co., 1528 East 53rd St., Chicago, Ill.*

Please mention number 835 when filling out card

D-c. Relay

New "Type J" d-c. relay is plug-in type for installation where quick removal and easy replacement are desirable. Supplied with standard octal base plug; over-all length is 3⅝". Exclusive features are said to include: independent twin contacts, high current carrying capacity, large armature bearing area, efficient magnetic structure, high operating speed and large contact spring pileups.—*C. P. Clare & Co., 4719 West Sunnyside Ave., Chicago 30, Ill.*

Please mention number 836 when filling out card

Wire and Cordage Meter

New "Model 220" wire and cordage meter has a measuring wheel machined from cast iron to close diametrical tolerance. Idler roller with spring tension assures accurate measurement under any reasonable operating conditions. Machine-cut gears are used throughout. Dials are manually reset to zero. —*Olympic Instrument Laboratories, Cove, Washington.*

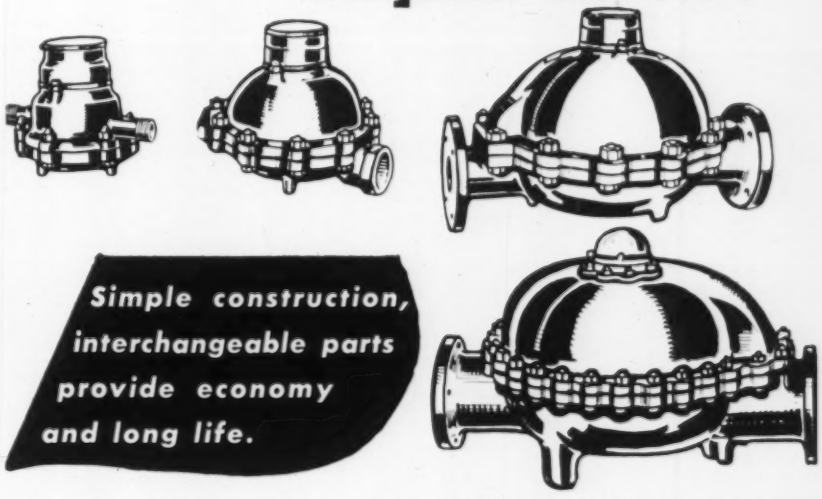
Please mention number 837 when filling out card

Tachometer Heads

New "Type 54" small light-weight tachometer heads are now available for use with standard SAE marine, diesel, and AN aircraft tachometer takeoffs. Heads can be used with any "Metron" tachometer indicators to give full-scale

NIAGARA

Displacement Type Liquid Meters



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Buffalo made single nutating piston displacement type meters are unequaled for their simplicity. They are made for three kinds of service:

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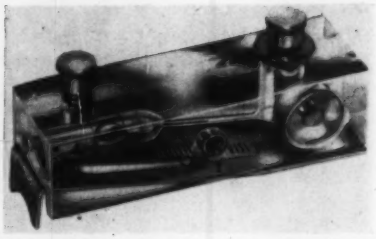
readings as low as 200 rpm. or as high as 10,000 rpm. Heads weigh 10 ounces, are 2⅛" in diameter and 4⅜" long. Maker claims they are adequately sealed, unaffected by vibration, magnetic fields, or temperature variations over a wide range. Operating torque approx. 1/20 ounce-inch for high-speed types and ⅛ ounce-inch for low-speed types.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number **838** when filling out card

Draft Gage

New model of "Visi-Draft" transparent draft gage incorporates a circular spirit level. With it, maker claims, heating sales or service man can obtain extremely accurate draft measurements for setting draft controls and also to line up burners and control valves into level operating position. "Visi-Draft" fits into the hand, hence can be used to level valves even in spaces usually considered too small to reach. Level is ⅝" in diameter; it indicates 1° out of level with each 0.1" bubble movement. All features of large draft gages are claimed to have been incorporated in this smaller version. Made from solid clear plastic. Scale is graduated in 0.01" divisions and easily read from above without danger of error.—*F. W. Dwyer Manufacturing Co., 6127 South Western Ave., Chicago 2, Ill.*



Please mention number **839** when filling out card

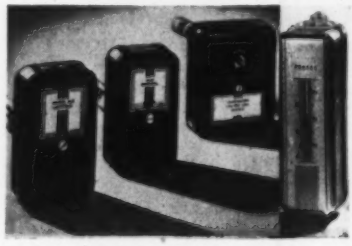
Round-work Micrometer

New "Ridermikrokator Frame 529" is intended for checking out-of-roundness and diameters of cylindrical parts. As measurements are carried out according to three-point principle, instrument can be used for checking centerless-ground pieces. Frames are made of malleable cast iron, are provided with hardened, ground and lapped anvils and insulating grips. Measuring surfaces of anvils can be tipped with cemented carbide. As angle between anvils is 60°, difference in radius between setting gage and work is measured, and tolerance pointer should therefore be positioned to half the limits required. Measuring instrument is a standard "Mikrokator No. 220" supplied with a removable "No. 524" measuring point sizes 1 and 2.—*Swedish Gage Co. of America, 8900 Alpine, Detroit 4, Mich.*

Please mention number **840** when filling out card

Thermostat, Fan Control, etc.

(1) New "Series 165 Magic Dial Thermostat" is designed to operate with maker's full line of primary controls in oil, gas, stoker or hand-fired coal heating installations. Both temperature and cycling adjustments are made on twin dials which permit user to compensate his heating equipment for sharp weather variations. Outstanding new features are completely enclosed twin contact switch and a separable wall-mounting plate which serves as wiring terminal.



(2) New "Series 404 Warm Air Limit Control"; (3) new "Series 454 Fan Control," and (4) new "Series 47 Combination Fan and Limit Control" all feature simplified design and completely-enclosed twin contact switches.—*Perfex Corp., 500 W. Oklahoma Ave., Milwaukee 7, Wis.*

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Two-scale Dial for Voltage Dividers, etc.

New "Duodial" has a primary knob geared to a turns-indicating secondary knob, complete unit requiring panel

space only 2" in diameter. Useful with voltage dividers, also to indicate angular position of slider contact on any given helix, also to control mechanical feeds that operate on a threaded principle. Available in turn ratios from 10:1 to 40:1.—*Helipot Corp., 1011 Mission St., South Pasadena, Calif.*

Please mention number 842 when filling out card

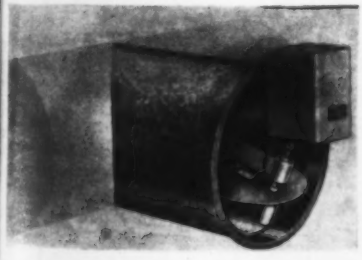
Pilot Light

New pilot light with "Multivue" cap is intended for use with the NE-51 neon glow lamp. Instead of being scattered by facets or concentrated by a lens, the light from the glowing electrodes is refracted in such a way that a multiple image is seen from any viewing angle. Resistor is built into assembly. Voltage may be 110 or 220 or higher, with small additional resistor. Connections are made to binding screw terminals, or to soldering lugs which are optional. Lucite caps are made in a full range of jewel-like colors.—*The Dial Light Co. of America, Inc., 900 Broadway, New York 3, N. Y.*

Please mention number 843 when filling out card

Sequence Draft Control

New draft control for use with domestic oil burners, oil-burning furnaces and boilers is said to be an aid in con-



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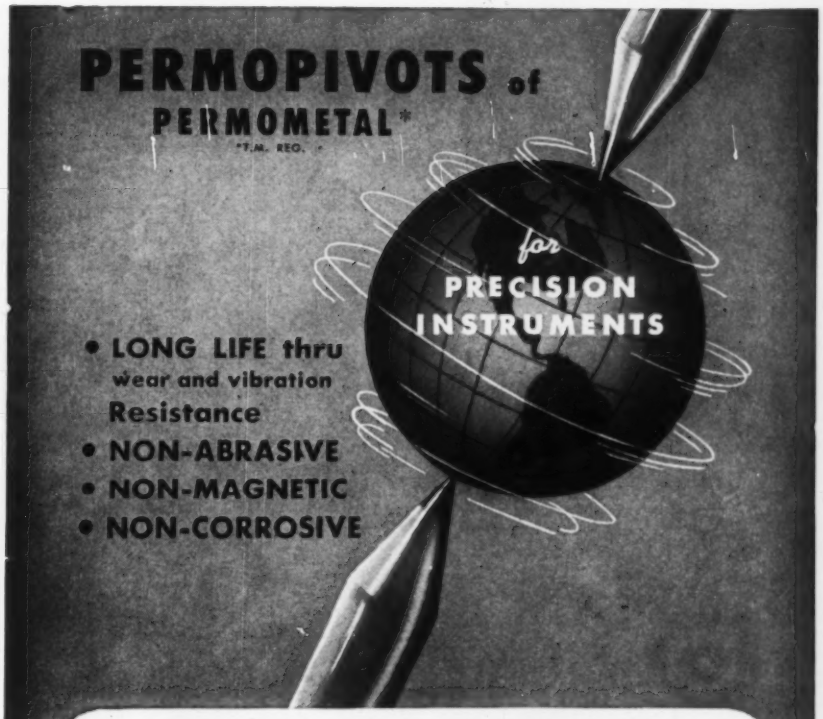

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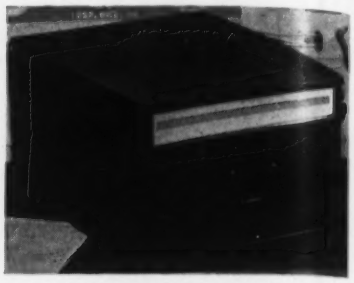
serving fuel oil. It consists of a barometric draft control plus a thermostatically activated sequencing unit to modify action of the barometric control during control periods when the burner is not operating. When the room thermostat is satisfied, it shuts off the oil burner and activates the sequence control which opens the barometric control after approx. 30 seconds. This gives time for the natural draft to clear heating plant of smoke, odor, and combustion gases; permits natural chimney draft to continue but causes it to bypass heating plant. Thus, stored warmth continues to be delivered into home instead of going up the chimney. Maker reports average fuel saving of 27.8%. Unit consisting of sequence draft control, 115/24-volt 60-cycle transformer and new standard barometric draft control complete with thimble. It may be used with any standard burner controls.—*Sampsel Time Control, Inc., Spring Valley, Ill.*

Please mention number 844 when filling out card

Light-beam Wattmeter

New light-beam wattmeter provides readings in the low-wattage, low-power-factor ranges for frequencies of 25-3000 cycles. Wattmeter's portable construction, high sensitivity, and low instrument losses make it applicable in cases where conventional wattmeters and pivoted type dynamometers operate under definite limitations. Can be used as transfer standard from d-c. to a-c. current wattage for calibrating other wattmeters and in production testing for such devices as small reactors, relays, Selsyns, fluorescent lamps, fluorescent lamp ballast, and core-cross measurements. Available in a large high-sensitivity model and a smaller model. Scale, approx. 11" long, on a multi-range instrument usually is calibrated for lower-current circuit and



150-volt potential circuit. Indicating element is built on the air-core electrodynamic principle with a taut suspended air-dampened moving element. A beam of light, triple-reflected from front-surface mirrors, produces a sharp line image on translucent scale, helps provide high sensitivity and permits full-scale indication with only a 7° angular deflection of moving element. Full-scale wattage is indicated at power factors as low as 0.08, full-scale indication obtained at ratings as low as 2 watts for 120 volts operation.—*Meter & Instrument Div., General Electric Co., West Lynn 3, Mass.*

Please mention number 845 when filling out card

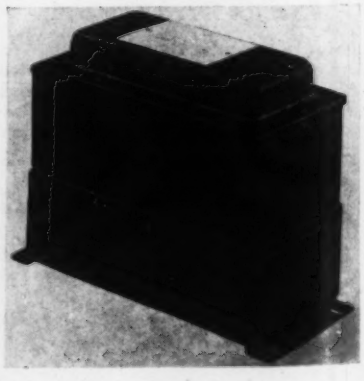
Precision Camera for Testing Photographic Lenses

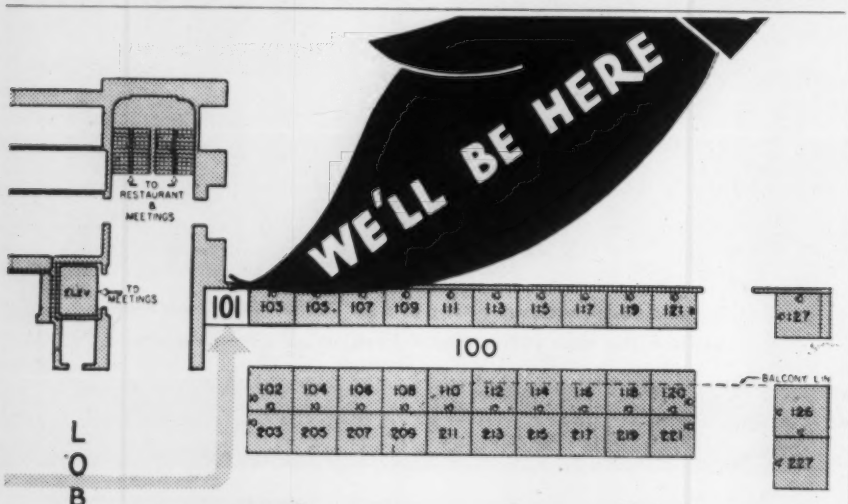
New precision camera for testing exact qualities of new lens formulas maintains parallelism between film plane and lens board to within 0.0005". A built-in microscope assists critical focusing. Negatives of photos taken with the camera may be quickly compared with test charts to measure resolving power, curvature of field, astigmatism and distortion. — *Bausch & Lomb Optical Co., Rochester, N. Y.*

Please mention number 846 when filling out card

Voltage Stabilizers

New "VR-6000" automatic voltage stabilizers for precise a-c. line voltage stabilization are said to have the following features: Magnetic type—space and weight saving—designed for "building-in" as integral part of elec-





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Please mention number 847 when filling out card

Electrical Test Set

New "Series 40" pocket-size wide-range circuit tester for use by service technicians, production inspectors, etc.,

is built into a Bakelite carrying case 3¾" × 6¼" × 2½", yet is said to offer every advanced design feature and full-bodied components regularly incorporated in maker's larger multi-range test sets. Unit affords 31 a-c. and d-c. ranges to 6,000 volts, 600 ma, + 70 db and 5 megohms.—*Precision Apparatus Co., Inc., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y.*

Please mention number 848 when filling out card

Magnetic Gas Valve

New "Type K-3H" hermetically-sealed magnetic gas valve is said to eliminate possibility of gummy or foreign

matter forming in solenoid and restricting plunger operation. A diaphragm construction seals operator from fuel gas without interfering with valve operation. Valve closes automatically upon current failure. Valve opens and closes a gas fuel supply line in response to room thermostats, limit controls or similar devices on warm air furnaces, gas-fired boilers, industrial furnaces, conversion burners, and most domestic heating appliances. Available in sizes from ⅜" to 1¼" IPS. inclusive. A

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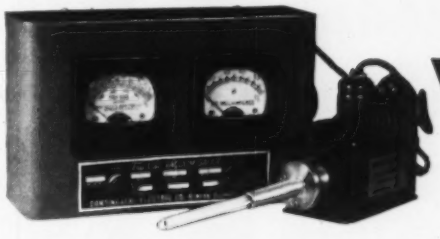

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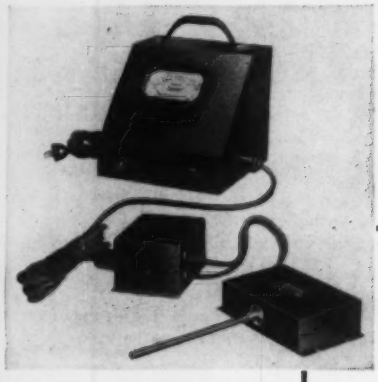

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simple lever-type manual operating device permits setting valve in open position in event of current failure. The same lever may be used to close the valve manually. Upon resumption of current an electric trip automatically returns valve to normal control.—*General Controls Co., 801 Allen Ave., Glendale 1, Calif.*

Please mention number 849 when filling out card

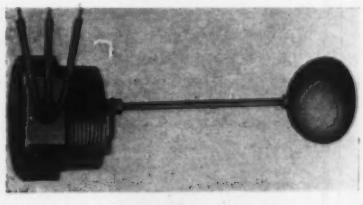
Electrometer

New electrometer is said to incorporate exceptionally high sensitivity, stable zero, linear response, small input capacity and high input resistance. Mounted in a portable metal housing, unit contains all necessary batteries, lead-in terminals, meter, amplifier and controls for measuring potential, current or charge, or as a balance indicator. It also measures extremely small currents, from 10^{-4} to 10^{-13} ampere, and may be applied to measurement of control grid secondary emission currents, residual gas ionization currents and other low-current phenomena in vacuum tubes. In measurement of very high resistance, range may be extended to 10^{16} ohms using a high-potential source and a standard shunt. Input resistance is greater than 10^{14} ohms, input capacitance is 8 mmf., and drift current is less than 10^{-14} ampere. Indicating instrument may be used separately, at a resistance of 10,000 ohms per volt.—*Central Scientific Co., 1700 Irving Park Road, Chicago, Ill.*

Please mention number 850 when filling out card

Magnetic Proximity Switch

New snap-action switch utilizes magnetic proximity principle, is especially designed for automatic-control service

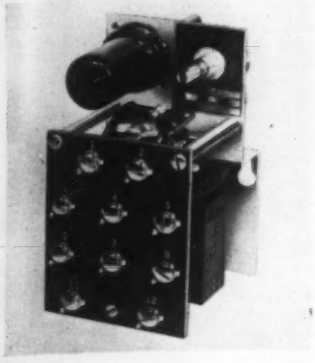


It contains an Alnico permanent magnet element whereby it can be actuated without physical contact. Housed in a simple metal canister, switch is available in a number of standard and custom-built mounting styles, with s-p.-d.-t. action adaptable to many uses. A typical use is in a new line of float switches for liquid level control service: switch is separated from float parts by a heavy non-magnetic stainless-steel plate which serves as a pressure barrier; float member is fitted with a magnetic stainless-steel element located near pivot point and a differential adjustment for varying leverage. New "Magneswitch" has withstood 2,000,000 operations on a 115-volt 1-ampere non-inductive load without failure. Rated to handle a-c. motors up to ¼ hp., it has been sed on ½ hp. pump motors under load for 30,000 operations before failure.—*Magneswitch, Inc., 4207 So. Western Blvd., Chicago 9, Ill.*

Please mention number 851 when filling out card

Liquid-level Controller

New model of "Leveltronic" relay for liquid level control is constructed so that direct or reverse action is pos-

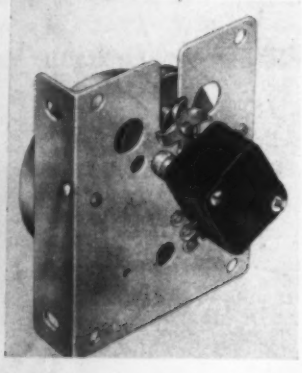


sible. This feature provides fail-safe action on line failure, or tube becoming inoperative, company states, thereby protecting against overflow or underfilling of process units. Out-contacts on the relay may be used to sound alarm, light a signal, or shut process down. Changing from one type of action to the other can be accomplished by using only pliers and soldering iron.—*Dept. DC., R-S Products Corp., Wayne Junction, Philadelphia 44, Pa.*

Please mention number 852 when filling out card

Flasher-type Timer

New "No. 5400 Interrupter (Flasher) Timer" is for applications requiring current in pulses of constant and



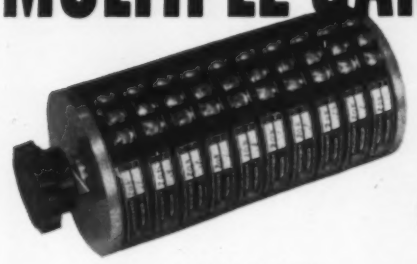
predetermined accuracy. Particularly applicable to electrical heating or cooking circuits, in communications where signals of set length are to be repeated regularly, etc. Unit is 3" high, 2-5/16" wide, 2⅛" deep. Micro-switch rated 5 amps. at 125 volts a.c. Motor drives cam at constant speed, and current is fed intermittently to controlled circuit in equal on and off periods. Range is from 72 pulses per minute to 1 pulse every 2 minutes. — *Haydon Mfg. Co., Inc., Torrington, Conn.*

Please mention number 853 when filling out card

Field Intensity Meter

New "Type WX-2A" portable field intensity meter—said to be the smallest and lightest unit of this type yet developed—weighs approx. 12½ lbs. (with batteries) and is 12" × 8½" × 7½". It provides direct readings, making it unnecessary to make computations of any kind. Instrument con-

MULTIPLE GANGING



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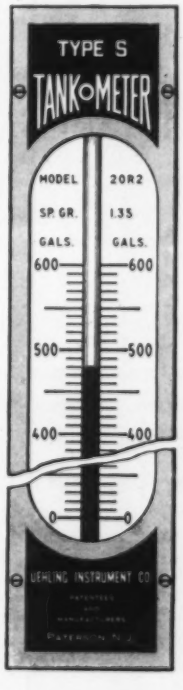

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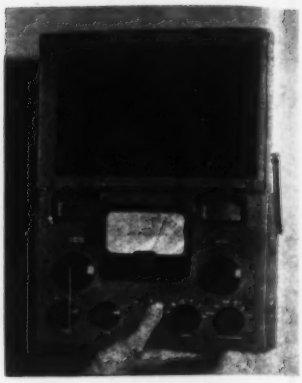


tains built-in calibrating oscillator and has a range from 10 μv./m. to 10 v. m. in standard broadcast band (540 to 1600 kc.); is particularly useful in rough terrain where field truck cannot be driven. Unbalanced loop antenna is integral part of cover. Unit employs ordinary flashlight cells to supply filament voltages, and a 67½-volt battery. —*Radio Corp. of America, Camden, N. J.*

Please mention number 854 when filling out card

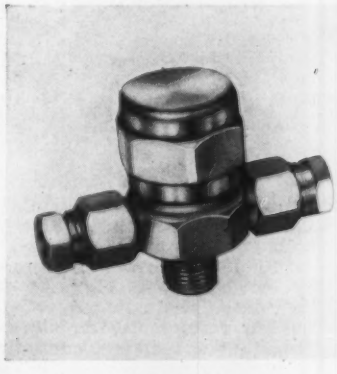
Two-stage Vacuum Pump

New "Model 1397B Duo-Seal" vacuum pump has a capacity of 300 liters per minute; produces vacuum of 0.1 microns; is said to be quiet in operation, free from backing oil and convenient for changing oil. Unit is 26" long, 14½" wide, 18½" high and weighs 22 lbs.—*W. M. Welch Co., 1515 Sedgwick St., Chicago 10, Ill.*

Please mention number 855 when filling out card

Metering-type Lubricator Valve

New "Grannan Lubricator", is a lubricator valve said to deliver a positive metered amount of oil or grease to each



bearing in lubricating systems; dispenses all lubricants from light oil to heavy greases without alteration. It is of through-flow type with no pockets or crevices; is completely enclosed to prevent leakage and possibility of contamination; is installed directly into the bearing; does not require special guns: will function either with hand-operated guns or from a completely automatic system. Operating temperature is from zero to 300°F.—*Titeflex, Inc., 730 Frelinghuysen Avenue, Newark 5, N. J.*

Please mention number 856 when filling out card

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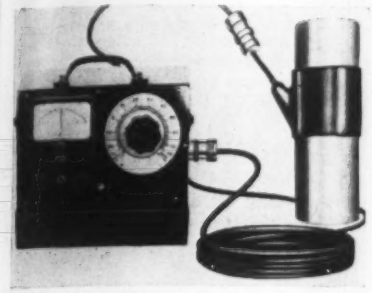
Weight Indicator

New "Model 500A" is designed for measuring operations in which tension load does not exceed 75 tons nor com-



pression load exceed 150 tons. Recommended for controlled setting of cement retainer, bridging plugs, fishing operation, etc., by rig operators or service crews. Operates on null balance principle and translates electrical impulses from connecting sub into weight readings. Provides coarse and fine adjustments of instrument balance. Subs are equipped with electrical strain gages and compensated for internal pressure effect. Standard sub is 2½" double-box 8-thread round external upset unit. All leads on sub are fully protected by heavy, vulcanized rubber sleeve. Working parts of instrument are within 2% of full-scale load. Maker claims temperature changes have no effect on accuracy of readings and there are no changes in readings due to variations of fluid pressure within sub.—*Byron Jackson Co., Oil Tool Terminal Annex, Box 2017, Los Angeles 54, Calif.*

Please mention number **857** when filling out card

Rotary Solenoids

Two new "Ledex Rotary Solenoids" are added to maker's line. Operating principle was described in *Instruments*,

Sept. 1945, page 669. New "No. 7" is 2¾" in diameter, weighs less than 2½ lbs., and produces a starting torque of 25 pound-inches with a 45° rotary stroke. New "No. 8" is 3⅜" in diameter, weighs slightly over 4 lbs., develops a starting torque of 50 pound-inches with a rotary stroke of 45°, thus has ten times more power than original model. Both units are said to have maximum magnetic efficiency. A dustproof cover, a self-contained scroll-type return spring, and other extras are optional. In quantity runs, however, extras may be custom-engineered to meet individual requirements. A choice of

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When wood moisture is above equilibrium with the prevailing atmosphere, there is a drying gradient. Moisture distribution is as important as average content. *Our gauges may be equipped with instantly interchangeable electrodes, both point and surface contactors* —the latter not only for testing thin veneer, but also for testing thick wood, in conjunction with the point contactor, to detect and determine moisture gradients rapidly without cutting the wood. Each gauge serves all purposes. No other meters are so versatile and so accurate.

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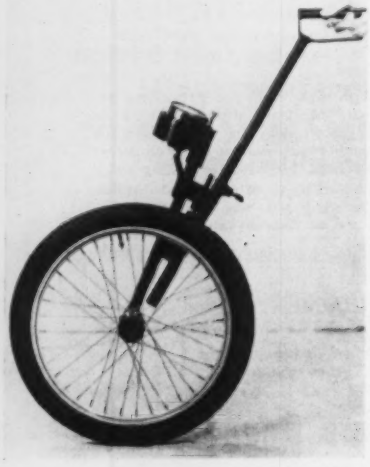
Furnished in three assemblies.

TRANSMISSION MODEL, for installation on the steering post of any car or truck, operates through a dual adapter at the speedometer outlet on the transmission and may be operated at will while the car is in motion.



PUSH MODEL, for pedestrian use over short courses. Operates with a wheel, as illustrated herein, has an adjustable, telescoping handle, and a convenient BRAKE which holds the wheel steady when operation has ceased.

TRAILING MODEL, a quickly detachable unit operated with a fifth wheel (bicycle type) which may be attached to either the rear bumper or side running board. The instrument temporarily mounts on steering post or car door.

These instruments can also be furnished in RODS, known as the RODOMETER, and in METERS AND KILOMETERS, which we call our METRIC SURVEY METER.

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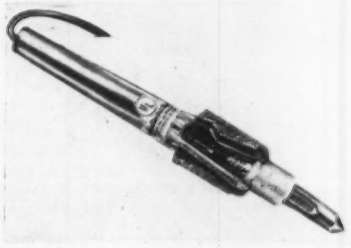
wire sizes from #13 to #35 represents d-c. operation from 6 to 550 volts. Rectifiers can be supplied, as accessories, for solenoid operation on a.c.—*G. H. Leland, Inc., 143 Webster St., Dayton 2, Ohio.*

Please mention number 858 when filling out card

Instrument Soldering Iron

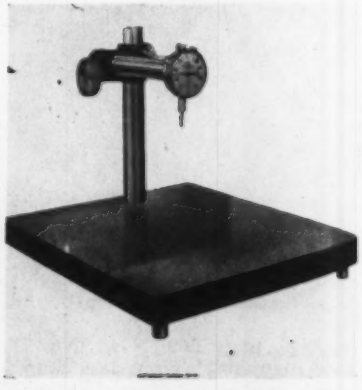
New 3.6 oz. soldering pencil is said to assure tightness and guarantee contact. Coolness is claimed for special plastic handle because both a cork insulator and cooling fins are used. A ceramic separator eliminates possibility of short, according to manufacturer, and a spring-action rivet takes up expansion to keep positive contact with heating unit. Element is 20 watt for use with 110-120 volt a.c. or d.c. Four interchangeable tellurium tips: ⅛" chisel, ⅛" pencil, ⅝" chisel, and ⅜" pyramid. Copper tip length beyond heating coil is ⅝" on ⅜" tips and ⅞" on ⅛" tips. Both heat to 600° in 90 sec.—*Tool Co., Los Angeles 54, Calif.*



Please mention number 859 when filling out card

Comparator for Checking Heavy Work

New "No. 130" heavy-duty type dial comparator is said to be especially useful for applications requiring checking comparatively heavy parts, such as large-diameter shafts, etc. Base is solid 1"-thick steel, with three-button support to prevent rocking on bench. Solid steel 1¼"-diameter upright post is fixed to base. Heavy, positive upright post clamp has large-diameter locking screws. Steel 1"-diameter indicator bar has its own clamp, allowing indicator reach and adjustment to be made without changing post clamp's vertical position. As a supplement to post adjustment, for close setting of indicator

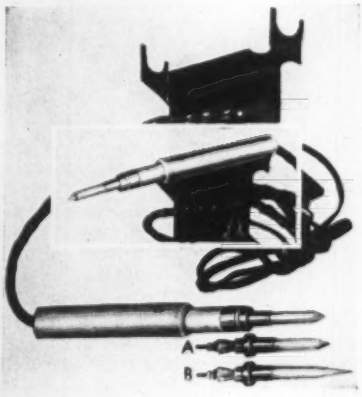


pointer on dial, there is available a special Vertical Adjustment which attaches to back of indicator. Any size or range "Hundred Series" indicator can be supplied. Base is available in any size, such as 10" × 10", 10" × 14", 16" × 16", etc. Upright post can be furnished in any desired height.—*B. C. Ames Co., Waltham 54, Mass.*

Please mention number **860** when filling out card

Instrument Soldering Iron

New "Soldetron" featherweight soldering iron weighs 3 oz., has following new features: Interchangeable tip-

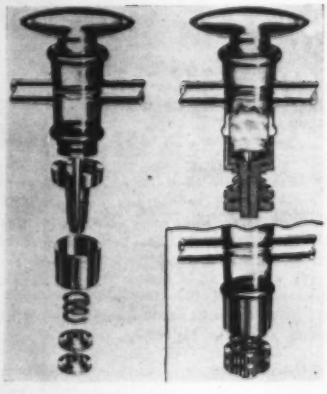


heads; no cleaning or filing; fingertip control permitting long soldering periods without fatigue; low current drain; heats up within 20 seconds from a cold start; cools upon release of button; quickly reheats when button is pressed. Iron comes ready for attachment and operation on 110-volt a.c. through transformer supplied with iron or 6-8 volt a.c. or d.c. without transformer (from an automobile battery). Choice of 3 tip-heads—long, stubby, or medium. Overall size 9¼" × 15/16". — *Transvision, Inc., New Rochelle, N. Y.*

Please mention number **861** when filling out card

Stopcock Adapter

New "Hamilton Stopcock Adapter" is said to eliminate "high additional expenditure for special pressure stop-



cocks." It is designed for use with any ordinary glass stopcock. This adapter has a split combination screw and bushing which fits over groove at end of the stopcock plug. An inner ridge locks into groove of plug when the two sections are brought together. A cup

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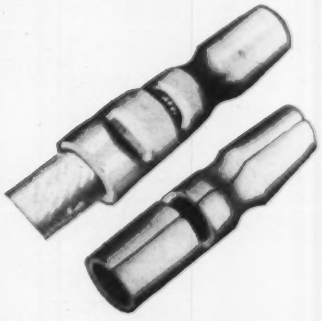
with a hole in its base fits over combination screw bushing, locking two parts of bushing securely in the groove. A spring fits over screw and presses against cup, insuring that latter is tight against shell of stopcock. A containing nut allows pressure applied by spring to be varied.—*Emil Greiner Co., 161 Sixth Ave., New York, N. Y.*

Please mention number 862 when filling out card

Solderless "Plug-in" Terminals

New "Shur-Plug" solderless plug-type terminal for 16-14 wire size provides convenient method of installing



or replacing connections on leads in electrical instruments, etc. Application to wire is accomplished in seconds by means of an "AMP" hand tool, pneumatic hand tool, or by foot or power presses. — *Aircraft-Marine Products, Inc., 1568 N. 4th St., Harrisburg, Pa.*

Please mention number 863 when filling out card

ELEMATIC THERMOCOUPLE

MODEL 4000 — for wall type indicator or recorder. Has flexible arm adjustable to any angle without use of tools

For Instantly and Accurately Checking the Temperature of all Nonferrous Molten Metals

"METALAST" SPEEDY tips are made of a special heat-resisting alloy which will give SPEED plus DURABILITY plus ACCURACY.

METALAST SPEEDY JUNIOR—¼" pipe size, for quick response—thermocouples are made of 16 gauge wire.

METALAST SPEEDY STANDARD—½" pipe size, heavy duty—thermocouples are made of 8 or 11 gauge wire.

Tubes may be straight, as well as 45 or 90 degree angles.

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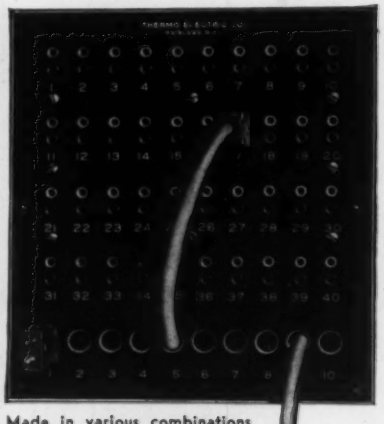

Made in various combinations of jacks and plugs, provide a quick and flexible method for easily connecting groups of thermocouples to pyrometers. Ideal for Pilot Plant use. Positive spring Jacks and Plugs made of standard thermocouple materials.

Write for complete information.

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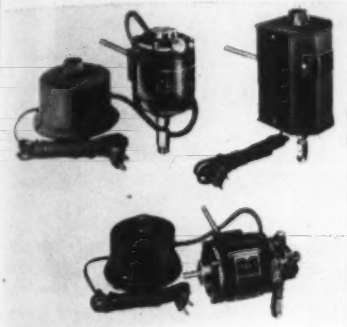

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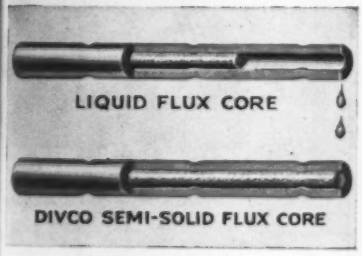

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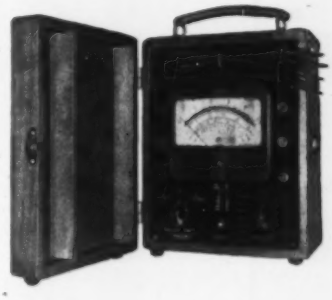

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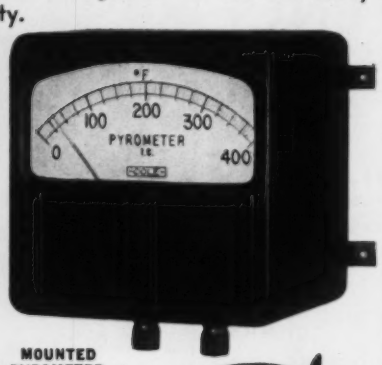

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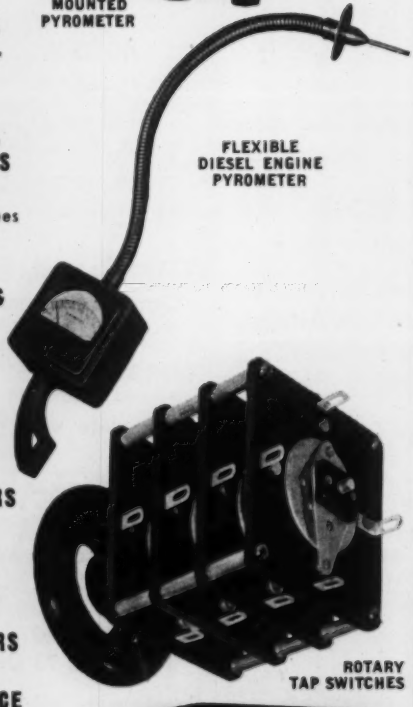

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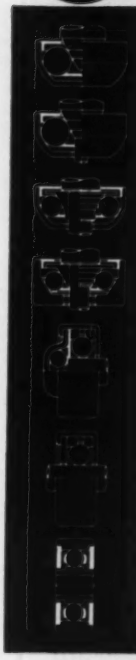

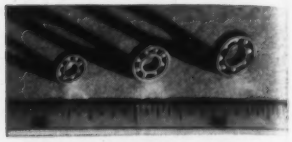

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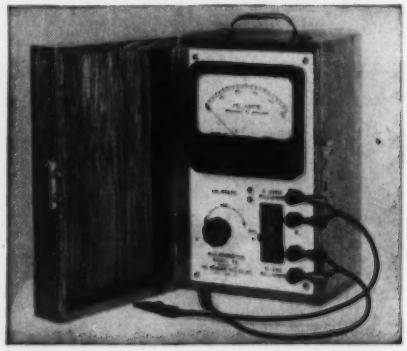

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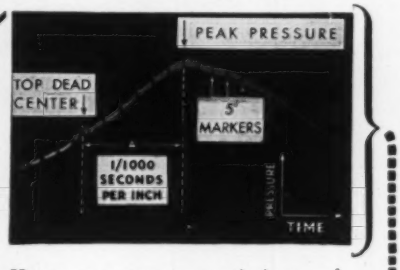

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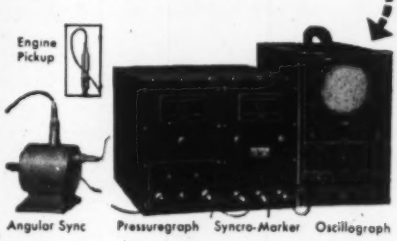

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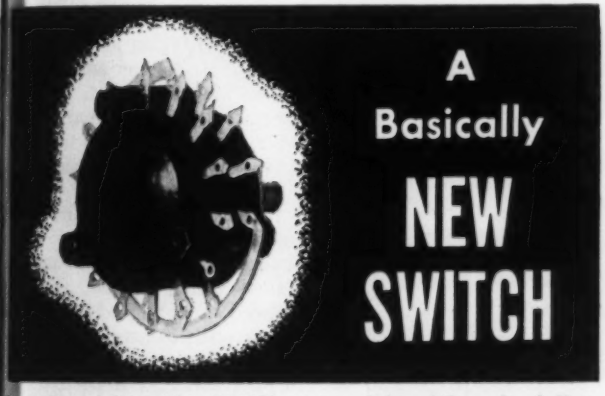

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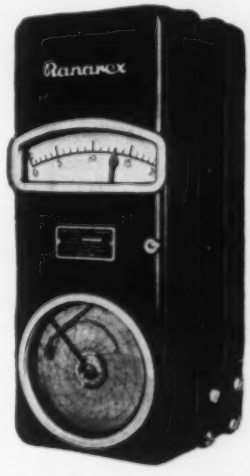

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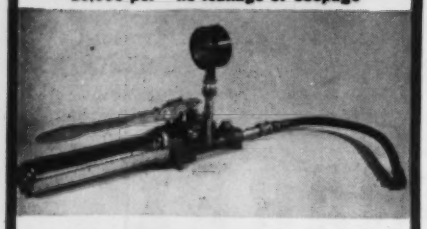

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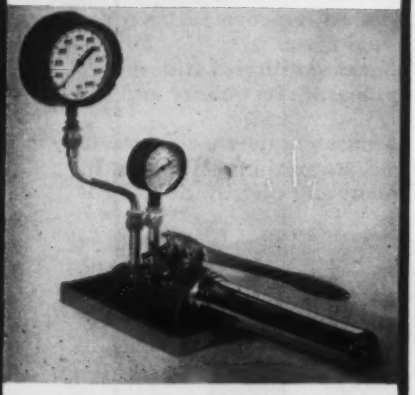

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INSTRUMENTS ON THE MARCH

Magnetic Fluid Clutch to Improve Servomechanism Performance

WASHINGTON, D. C.—According to Technical Report 1213 of the National Bureau of Standards, a new type of electromagnetic clutch, having extensive applications and many unique features, has been developed by Jacob Rabinow, Chief of the Bureau's Ordnance Mechanics Section. The development of this clutch, which is based on Rabinow's discovery that frictional forces between solid surfaces and certain types of fluid media can be controlled by application of magnetic fields, was part of the work on the mechanical aspects of the high-speed electronic digital computers being built at the Bureau for the Office of the Chief of Ordnance, Department of the Army.

Characterized by ease of control, high efficiency, smooth operation, long life, and simplicity of construction, the new magnetic fluid clutch is particularly suitable to applications in servomechanisms, automatic machinery and many other fields where ease of control and constancy of characteristics are important. Mr. Rabinow has assigned all patent rights for the clutch to the U. S. Government.

Principle of New Clutch

The magnetic fluid clutch operates on the following basic principle: When the space between two parallel magnetic surfaces is filled with finely-divided magnetic particles and a magnetic field is established between the two plates, the magnetic particles bind the plates together against movement parallel to their surfaces. The magnetic particles may be finely divided iron which, for most applications, is mixed with a liquid, such as oil, to prevent packing and to afford smoother operation of the clutch. When a portion of this mixture is acted on by a magnetic field, and the mixture seemingly "solidifies"—an effect readily demonstrated by lowering a small permanent magnet into a beaker of the iron-oil mixture. As the magnetic field can be produced by an electric current, a simple means is thus obtained for the control of the binding force over a very wide range.

Advantages

Preliminary results at the NBS indicate that the electromagnetic fluid clutch has numerous advantages over many other existing types. Its action and its control are both "smooth." Its action is smooth because all contacting surfaces, both of the plates and of the iron powder, are coated by a lubricant. It is easy to control and requires very small amounts of electrical power. Its control is extremely smooth from the minimum, which is determined by the viscous drag of the oil, to the maximum, which is controlled by the magnetic saturation of the iron. In other electromagnetic clutches, torque follows a square law, being proportional to the square of the electric current; but in the new clutch the torque is proportional to the control current over a wide range of torque values. Hence, the clutch is particularly suitable to servomechanism applications where linearity and good control down to zero current are of prime importance.

Another unusual and desirable feature found in some forms of the magnetic fluid clutch is that the value of static friction does not differ appreciably from the value of kinetic friction; hence no discontinuities in torque exist at the instant of initiation of slip. This feature is one of the principal reasons for smoothness of the clutch action, since chattering in an ordinary dry friction clutch is mainly due to the difference between static and kinetic friction.

Because it has no axially moving parts, the clutch is easy to build, consisting essentially of a driving and a driven member which do not change relative position, except in rotation. As slipping occurs only between fine iron particles and between the iron particles and smooth face surfaces of the clutch, and as all the surfaces are lubricated, wear is practically non-existent. Moreover, if any of the surfaces are worn off, the iron dust thus generated simply adds to the iron powder already in the oil mixture. The gaps, as normally employed, are fairly large; therefore, such wear will have negligible effect. In the clutches tested at the Bureau, no wear has been noted, but because extensive life tests have not yet been run, it is not possible to rule out wear completely.

Other Torque Couplings

There are numerous types of mechanical and electromechanical coupling in existence, but only coupling devices employed for continuous control of torque need be considered here. Of the controllable-torque devices, where slippage is employed to dissipate any

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desired portion of the power, the four most commonly-used types are the mechanical dry friction type, the fluid coupling type, the electromagnetic, and the electrostatic clutch.

(1) The mechanical dry friction clutch is the best-known. In general, such clutches are not suitable where continuous slippage is desired, as in servomechanisms. Rapid wear, difficulties with heat dissipation, and non-uniformity of results, are the principal deficiencies.

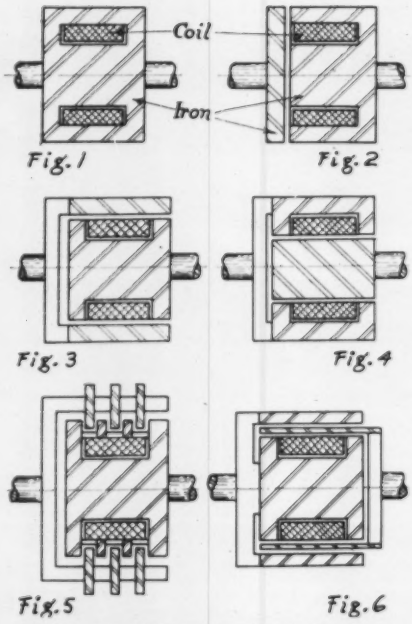
(2) For services where smooth slippage is important, the fluid-coupling type is superior. As used in automobiles and in some servo systems, it is not really a friction clutch but comprises a centrifugal pump so coupled to a turbine that changes in torque can be obtained by changing the speed relation between the two main members. This type is extremely difficult to control with external means, particularly when high speed of control is desired. Furthermore, such devices cannot be locked completely, so that some loss of energy (and consequent angular error) must occur.

(3) Electromagnetic clutches are simply devices wherein the driving member contains one portion of the magnetic circuit, while the driven member contains iron which completes the magnetic circuit. The frictional forces can be transmitted directly through the iron faces or through special frictional materials. These clutches are extremely rapid in operation, relatively simple and easily controllable, but suffer from the difficulties of heat dissipation, wear, and lack of smoothness—effects common to all dry friction couplings.

(4) The electrostatic clutch, seldom used except for extremely high-speed operation, employs electrostatic attraction between very-closely-spaced surfaces to achieve the same result accomplished by use of the magnetic field in the magnetic clutch. The remarks on wear applicable to other dry clutches also hold here. The clutch, generally used in small sizes, requires high voltages, but can be operated with very low control power at extremely high speeds. In another type of electrostatic mechanical coupling, patented by Willis M. Winslow, particles of dielectric material are suspended in an insulating fluid contained between metallic plates. This clutch requires the application of high voltages and the use of close spacing between the elements.

Design Possibilities

Before describing magnetic clutches built and tested at the Bureau, it may be well to generalize on the design of such couplings. Fig. 1 shows the general arrangement of an electromagnetic clutch where both the driven and the driving members are represented as a single unit. Figs. 2, 3 and 4 show three alternate methods of dividing the magnetic structure into two parts for the transmission of power. Fig. 2 is the configuration most generally employed in dry magnetic couplings, while Figs. 3 and 4 show alternate arrangements particularly suitable for the use of magnetic powder and oil instead of dry friction. Figs. 5 and 6 are other arrangements where the magnetic structure is cut at more than two places so that parallel plate operations may be obtained in order to increase the area of action. While all figures show a single coil, it is obvious that separate coils, spaced like the poles of an electrodynamic machine, may be employed. The single coil is favored because of its simplicity of construction and excellent magnetic efficiency. Many other forms of magnetic circuits can be employed, depending on the materials used, results desired, cost, and other factors.

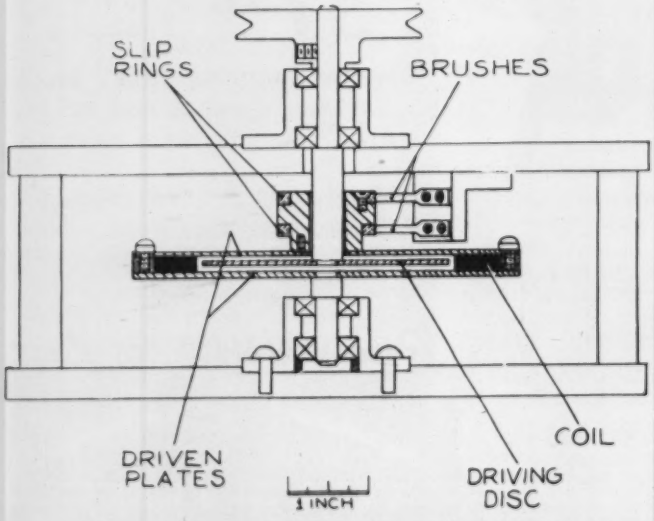


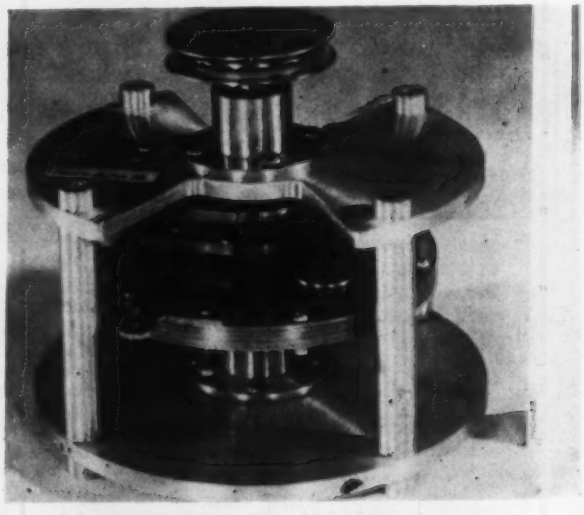
Figs. 1 to 6. Cross-sectional drawings of magnetic clutches showing various designs for such couplings.

The design principles of the magnetic circuit of the clutch are no different from those used in all other electromagnetic machinery, with the possible exception that the value of the permeability of a suitable mixture of the carbonyl iron and oil is approximately eight times that of air. A permeability of 8 implies that an iron powder gap of, say, 0.08" has the same reluctance as an air gap of 0.01". This increased permeability of the gap greatly simplifies the design and construction of practical electromagnetic couplings of the type described. The permeability was measured by means of toroidal coils wound around lucite rings containing a known quantity of the magnetic mixture. Higher permeabilities can be obtained by using less oil, larger particles, or aggregates of large and small particles, but it is doubtful that very much better values than those reported can be obtained with carbonyl E powder mixtures.

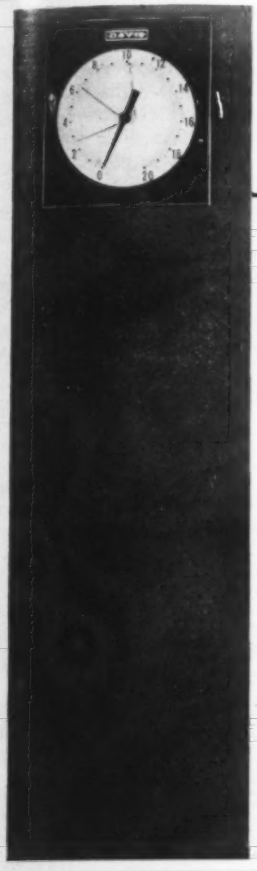
A consideration in the choice of gap dimensions is the viscous drag when the magnet is de-energized. In many cases it must be minimized; in an overload clutch it may be of no importance.

The magnetic clutches thus far built at the NBS are of simple form, with plate spacing fixed, producing appreciable viscous drag at high speeds when the clutch is de-energized. For one of the Bureau experimental clutches (Figs. 7 and 8), the drag is approximately 1.0 lb.-in. at 1000 rpm. and varies linearly with speed. This drag may be minimized in several ways, such as using a thinner mixture of iron and oil, using lighter oil, increasing the spacing between the plates, and,





Figs. 7 and 8. First NBS test model of practical magnetic fluid clutch, invented by Jacob Rabinow and assigned to the government for the use of all industry. The principle employed by this clutch offers advantages of importance in servomechanisms.



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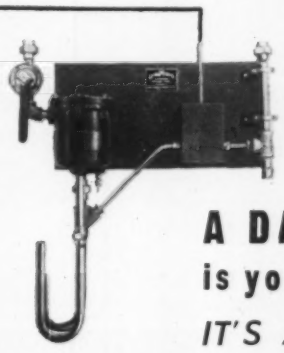

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of course, driving the clutch at lower speeds. Mechanical devices which change plate spacing automatically when the clutch is demagnetized can be employed, and the number of other expedients is unlimited. Normally this viscous drag is a small fraction of the clutch torque, and the heat generated can be readily dissipated. In automobile applications, the low idling speed of gasoline engines is advantageous.

The use of gaps in parallel, or single gaps of large area, entails large amounts of iron and small copper losses, whereas gaps in series reduce the amount of iron but require more excitation to overcome the total resultant gap length. Which method is preferable depends upon size, weight, the availability of electric power, etc. Multiple-plate clutches can be designed so that the sets of plates are either in series or in parallel. The clutch shown in Fig. 9 uses the series gap arrangement, is very compact, but heat dissipation presents special problems, particularly if the clutch is to be used continuously in a constantly-slipping condition. Air or liquid cooling can, of course, be provided in any known manner.

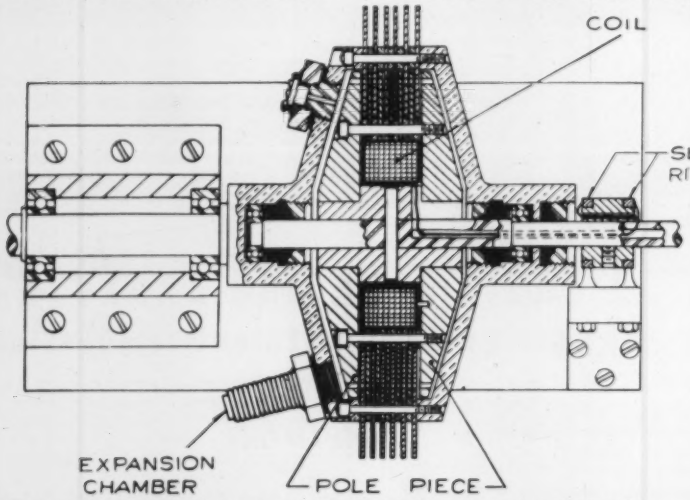
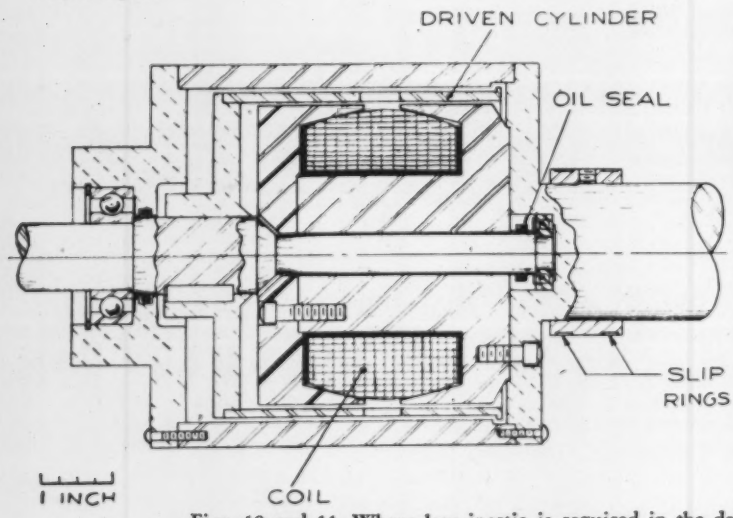
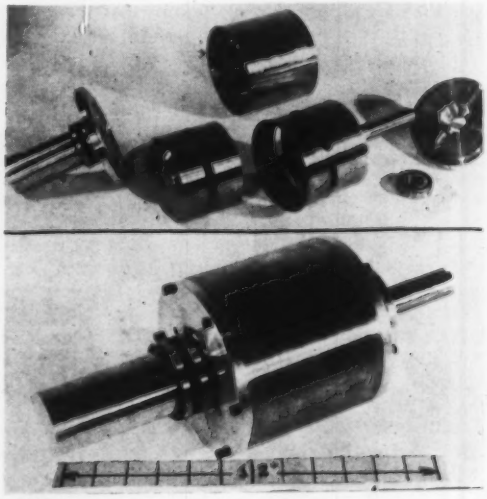


Fig. 9. Showing how a magnetic fluid clutch can be expanded to have any desired number of alternate driver and driven plates. This multiple-disk clutch is very compact.

Where low inertia is required in the driven member, as in high-speed servomechanism work, it is desirable to make the exciting coil and magnetic iron a part of the *driving* member insofar as possible. Only a very thin (low-inertia) member is then needed to pick up the torque in clutches such as shown in Figs. 6 and 10. The thin driven plate,





Figs. 10 and 11. Where low inertia is required in the driven member, as in high-speed servo work, it is desirable to make the exciting coil and magnetic iron a part of the driving member insofar as possible. The drawing shows a very thin driven member. This clutch, only 6" in diameter and 6½" long, transmits 40 horsepower at 3000 rpm.

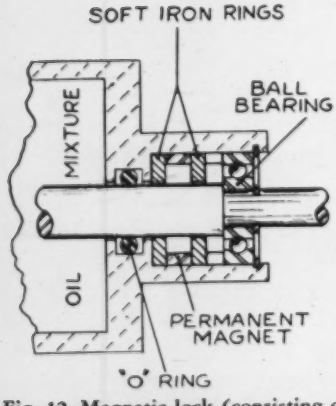


Fig. 12. Magnetic lock (consisting of a permanent magnet ring flanked by two iron washers) to prevent iron particles getting into the ball bearings.

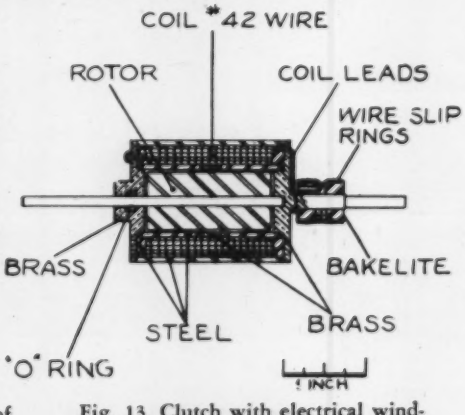


Fig. 13. Clutch with electrical winding on outside of the friction surfaces; an advantage where seals present difficulties, particularly with thin shafts.

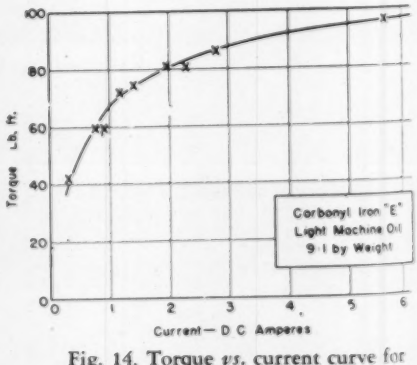


Fig. 14. Torque *vs.* current curve for the 6" O.D. clutch shown in Figs. 10 and 11.

normally made of iron or other magnetic material so as not to introduce any unnecessary reluctance into the gap, may be made of various *non-magnetic* materials as well. It was found that plates made of such materials, when introduced into the magnetic gaps, experienced torque because of the attraction of iron particles from opposite sides of the plates. It has been found that mesh or plates with perforations experience torques comparable to those obtained with iron plates. This effect is important because, when a thin iron plate is used, there is the possibility that mechanical eccentricities may be exaggerated by the magnetic pull and the plate deformed sufficiently to contact one or the other of the magnetic surfaces. This type of unbalance of magnetic pulls is well-known to the designers of rotating electrical machinery. The thin lip shown at the edge of the driven member of the clutch in Fig. 10 was built to stiffen the cylinder. By using non-magnetic materials this difficulty is obviated.

Another problem is that of sealing the oil-iron mixture. Good results have been obtained by using rubber "O" rings at the shaft bearing. No doubt other types of packing can be employed successfully. If there is danger of the iron particles getting into ball bearings, it may be desirable to add a magnetic lock beyond the oil seal: the iron-freed oil that passes beyond this point should have no harmful effect on the bearings. One form of magnetic lock is shown in Fig. 12.

Generally speaking, it appears advisable to place the electrical winding inside the clutch. There may, however, be times when seals present difficulties, particularly in the case of very thin shafts. Then the coils may be placed on the outside of the friction surfaces. Such a design is shown in Fig. 13.

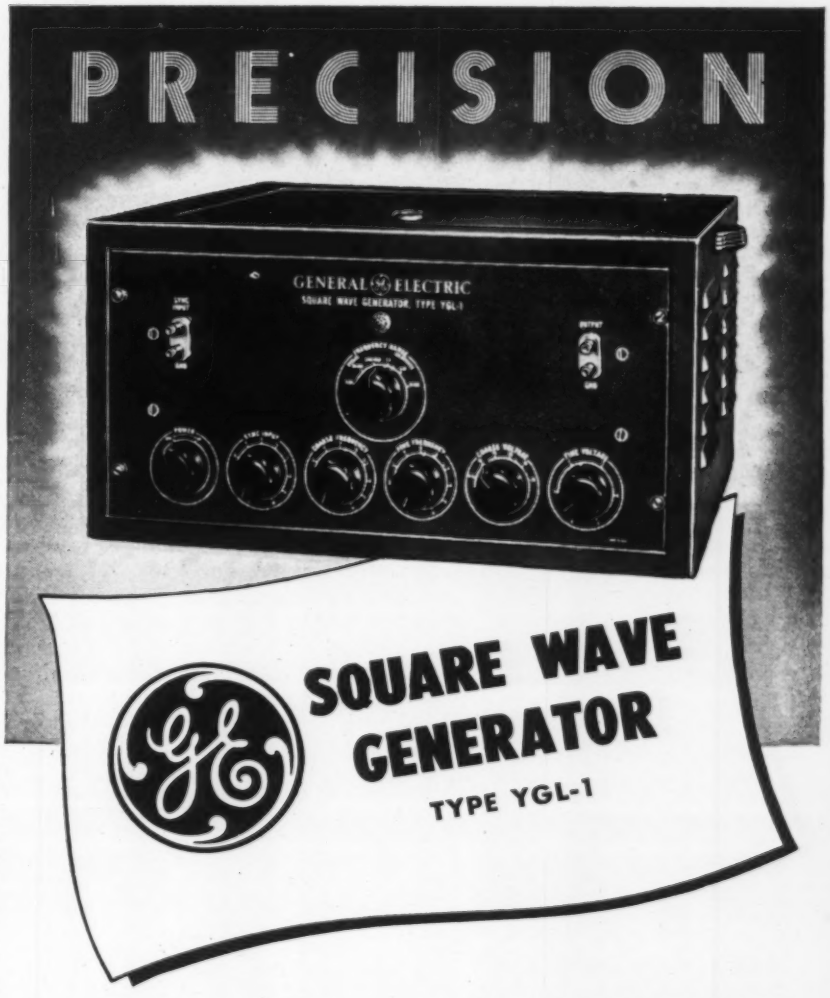
It is possible also to make the energizing coil completely separate from the clutch, so that the coil is not revolved but transmits the magnetomotive force to the working faces through short air gaps. This means some loss of electrical efficiency but it may be suitable for small sizes, where power demands are low.

When an electromagnetic fluid clutch is used as a brake, slip rings are not necessary.

Experimental Results

Various experiments were performed with the flat-plate clutch (Figs. 7 and 8), the magnetic components of which are made of 47% nickel steel. The inner driving plate is a disk 0.062″ thick by 3″ in diameter and the iron-oil gap on each side of the disk is 0.062″. The coil consists of approximately 200 turns of No. 28 wire with a d-c. resistance of 15 ohms. No effort was made to make an efficient magnetic circuit.

Tests indicate that the static friction is not appreciably different from the friction obtained under conditions of slip. In one experiment the torque was



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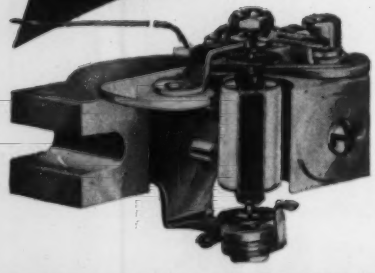

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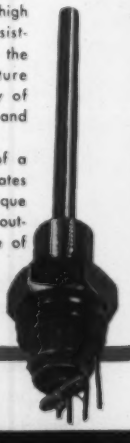

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measured on a spring scale attached to the rim of the driven plates by means of a thin cable. It was found that when the clutch was driven by the electric motor the pointer on the scale remained completely steady, indicating that the value of the torque did not drop with the increase in speed—an effect quite common in dry friction clutches, which usually results in considerable instability under similar conditions of test. As expected, the clutch heated up during each run, lowering oil viscosity but changing the torque only slightly.

Determination of the type of liquid to use as a vehicle is based on such factors as difficulty in sealing, ability to withstand high and low temperatures, chemical stability, availability and price. It was found that in this particular clutch a mixture of oil and carbonyl E iron, with an average particle size of 8 microns, gave the best results. This may not be true of other clutches or other conditions of tests.

Since speed of response is of paramount importance in servomechanisms, the time of build-up and decay of torque was measured by means of a wire strain gage attached to the rim of the driven member. The input voltage was applied to one pen of a multi-channel recorder while the strain gage was made a part of a 60-cycle bridge, the output of which was applied to a second pen of the recorder. The resulting twin record showed that the torque rose and decayed in approximately 1/30 second. In some previous tests with similar equipment, torque rise- and fall-times of the order of 1/60 second were obtained.

Following these experiments, two small clutches (Fig. 12) suitable for servomechanism work were built into a model auto bus. In order to keep the construction simple, the coil was placed on the outside of the clutch proper. It was found that a current of 8 milliamperes results in a torque of 2 lb.-in. This is the value at the knee of the saturation curve. A value of 3 lb.-in. is obtained with approximately 24 milliamperes. One of the clutches is locked to the frame and is used as a brake. By controlling the current through the clutch and brake, acceleration and deceleration can be easily controlled, and the car can be made to run smoothly at low speed. The brake action also is smooth and positive.

Basing the design on the results obtained with this fixture, a much larger clutch was built in the Bureau shops. This clutch is shown in cross-section in Fig. 10, assembled and disassembled in Fig. 11. The magnetic circuit is again of unannealed cold rolled steel with the end plates made of dural. The coil has 600 turns of No. 18 wire with a total resistance of 3.5 ohms. In order to keep inertia of the driven member low, most of the magnetic circuit iron and the coil were made part of the driving structure. The driven member consists of a 1/16" thick cylinder mounted on

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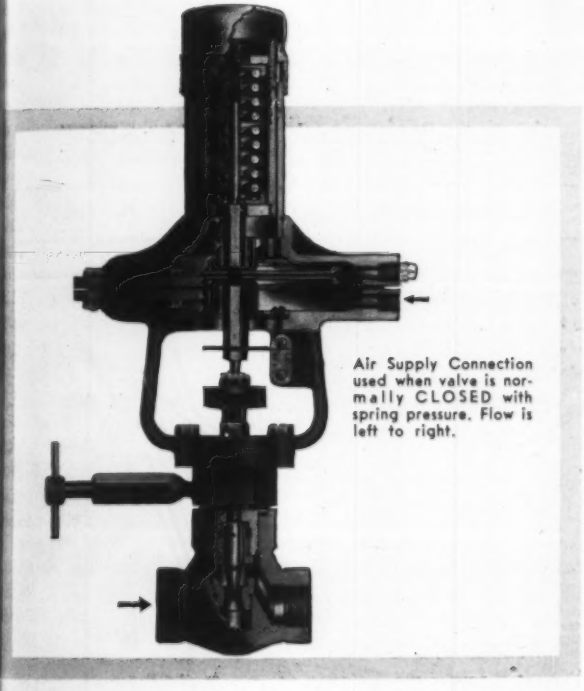
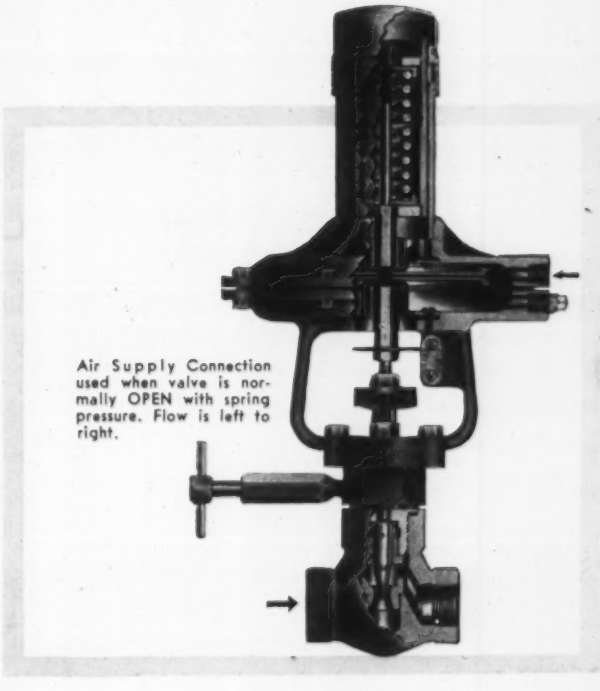


Air Supply Connection used when valve is normally CLOSED with spring pressure. Flow is left to right.



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brass disk which in turn is fastened to the driven shaft. Rubber "O" rings are used as seals. The relationship between torque and magnetizing current is shown in Fig. 14. No square law effect is apparent. Additional tests on this clutch are under way.

Applications

The results obtained by the NBS in the experiments on the several forms of the magnetic fluid clutch suggest many possible uses. The automotive application is obvious: the clutch is not speed-sensitive; if load is below slipping torque, no slippage occurs and mechanical efficiency is 100%. Easy controllability makes it attractive for use in automotive transmission. Since the amounts of electric power required to control the magnetic clutch are small, it is a simple matter to interlock the electric circuits with the speed, throttle setting, power demands, etc.

Symposium on Magnetic Materials

WASHINGTON, D. C.—On June 15 there were presented the first results of the efforts of a technical group established within the Naval Ordnance Laboratory to exploit the possibilities of new and improved materials. This important public disclosure took the form of a symposium, at which six technical papers were presented by members of the Laboratory's Magnetic Materials Group as well as by specialists from civilian laboratories.

The complete proceedings of this symposium will be published in the form of a paper-bound book early in August. This book will be available without charge to interested workers in the fields of servomechanisms, etc. The contents of this book will be as follows:

"Saturable Reactor and Magnetic Amplifier Circuits." — Frank G. Logan, Vickers, Inc.

"The Mechanical Rectifier."—Otto Jensen, I.T.E. Circuit Breaker Co.

"Some Factors Governing the Achievement of a Rectangular Hysteresis Loop."—Dr. E. Both, Squier Signal Laboratories.

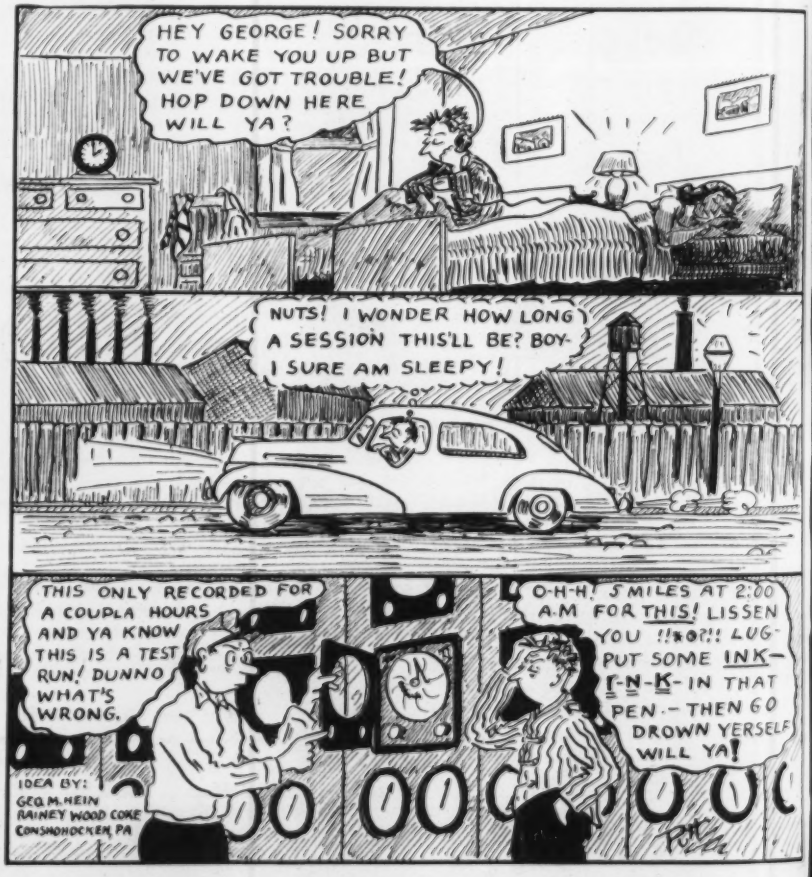
"Magnetic Program at the Naval Ordnance Laboratory."—Dr. G. W. Elmen, Consultant, N.O.L.

"Processing of Magnetic Materials at the Naval Ordnance Laboratory."—E. A. Gaugler, Chief of Magnetic Materials Group, N.O.L.

"Magnetic Amplifier Development."—A. O. Black, Development Engr., N.O.L.

WHEN A FELLER NEEDS CONTROL

By Phil Putnam


HEY GEORGE! SORRY TO WAKE YOU UP BUT WE'VE GOT TROUBLE! HOP DOWN HERE WILL YA?
NUTS! I WONDER HOW LONG A SESSION THIS'LL BE? BOY- I SURE AM SLEEPY!
THIS ONLY RECORDED FOR A COUPLA HOURS AND YA KNOW THIS IS A TEST RUN! DUNNO WHAT'S WRONG.
O-H-H! 5 MILES AT 2:00 A.M FOR THIS! LISSEN YOU !!*@?!! LUG- PUT SOME INK- I-N-K- IN THAT PEN.- THEN GO DROWN YERSELF WILL YA!
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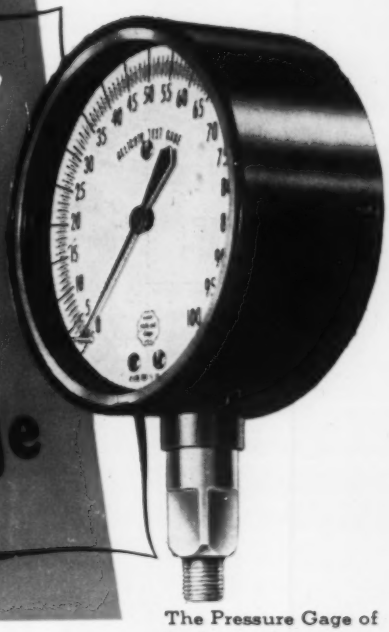

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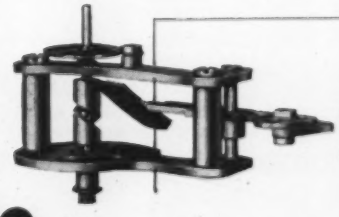

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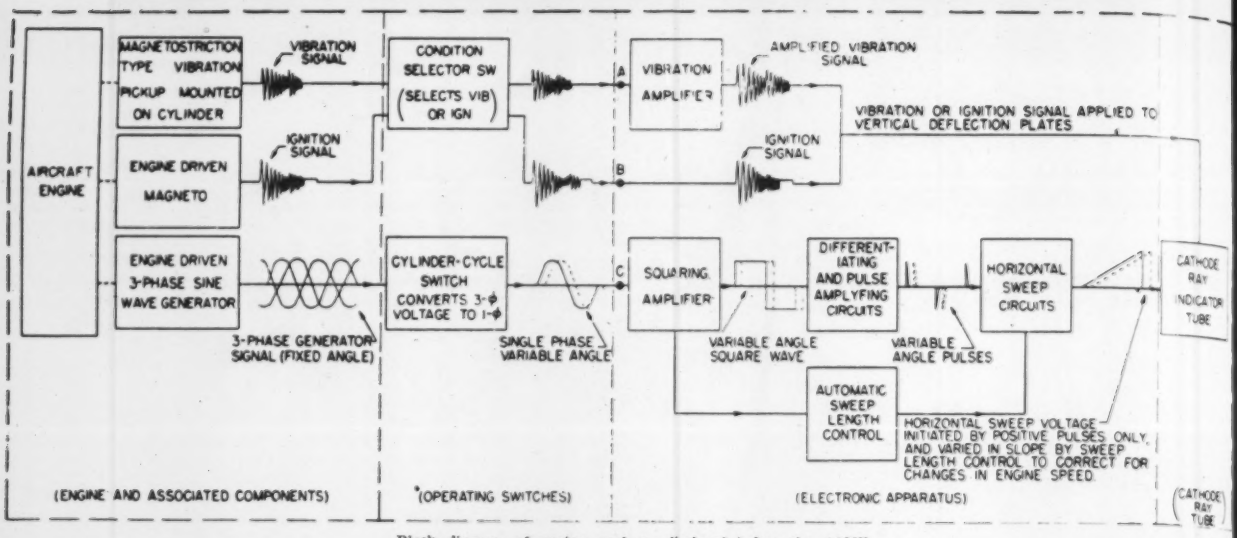
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A
B
C
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IGNITION SIGNAL
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Block diagram of engine analyzer disclosed before the ASME.

New Instruments for Planes and Gas Turbines Described at ASME Meeting

MILWAUKEE, Wis.—An airplane engine analyzer capable of diagnosing engine troubles while the plane is in flight has successfully met performance tests, it was disclosed before The American Society of Mechanical Engineers at its Semi-Annual Meeting here. James W. Wheeler, engine instrument engineer of the Sperry Gyroscope Co., said that with the analyzer, engine maintenance can be improved, schedule delays can be reduced, and increased dependability of operation will be made possible. These would ultimately result in reduced cost of air transportation.

The Sperry analyzer presents the engine data on a cathode-ray tube screen. The patterns on the screen can be interpreted simply by comparison with typical patterns obtained under known conditions. Location of the trouble is rapid. Ignition or mechanical difficulty, suspected on a particular engine, can be selected by the operator with one switch, while with a second switch he can locate and examine the cylinders in which the trouble occurs.

Engine difficulties, it was pointed out, often can be located only under conditions of continuous operation at high cruise powers.

Stressing the ease of operation of the analyzer, Mr. Wheeler continued: "As the pattern interpretation involved is quite simple, and no operations are involved in using the analyzer but switching, a complete check on an engine may be made in five minutes or less by an operator whose training time on the analyzer is less than one hour. Flight engineers familiar with the equipment can locate and identify several troubles on four engines in less than 15 minutes."

At the same technical session, cosponsored by the Aviation, Heat Transfer and Industrial Instruments and Regulators Divisions of the ASME, two other new instruments were reported.

R. G. Jewell of the General Electric laboratories at Lynn, Mass., described a remote-indicating pressure gage for indicating oil and fuel pressure of aircraft. It has overcome many serious problems such as those created by low temperature and severe engine vibration, he reported. The transmitter is mounted directly on the engine and the indicating system is unique in that only one lead wire and ground return is required between indicator and transmitter.

Work sponsored by the Bureau of Ships, Navy Department, on a new device for gas turbines was reported by Andrew I. Dahl and Ernest F. Fiock, physicists of the National Bureau of Standards, Washington, D. C., where the development and tests were carried out. This is a small radiation shield of silver, gold or platinum, for use in measuring exhaust gas temperature.

In gas turbines, now being developed as power plants for land, sea and air use, problems have arisen in the use of thermocouples for indicating gas temperatures up to about 2,000°F. In gas turbines the gases are normally much hotter than the surrounding walls, so that radiation from a thermocouple in the gas stream to the walls may cause error in observed values of gas temperatures. Effective radiation shielding of the measuring junction can be accomplished by pressing a small, tubular shield of silver, gold or platinum directly on an oxidized junction of base-metal, the scientists revealed. Their paper gave detailed results of service tests to date, made with a blower supplying air to a single combustor from a turbo-jet engine.

SCMA

New officers were elected to the Boa of Directors of the Southern Californi Meter Association at the Twelfth Annu Low-Jinks Celebration on June 17, 194

President, J. C. Groenewegen, Shell C Co.; *Vice President*, Edgar Valby, Richfie Oil Corp.; *Secretary-Treasurer*, Geo. F Forster, Jr. The Texas Co.; *Auditor*, Harr M. Kemmerer, So. Counties Gas Co.; *Pa President*, Curtis G. Cortelyou, Gener Petroleum Corp.

Chairmen of Committees: Program, Jam E. Adams, Signal Oil & Gas Co.; *Entertai ment*, Fred G. Carter, Fisher Governor C *Membership*, Robert F. Fields, So. Califo nia Gas Co.; *Publicity*, Oliver W. Mi Robinson Orifice Fitting Co.; *Standard* Bruce E. Powell, Standard Oil Co.; *B laws*, H. C. Smalley, Fullerton Oil Co.; *I strumentation*, Howard I. Anderson, S California Edison Co.; *San Joaquin Valle* Ross T. Furlong, The Texas Co.

At the July 15 regular meeting, Lou Possner, project engineer, College of Engi eering, University of California at Berkele spoke on "Thermal Radiation, Heat Flo and their Measurements."

An official of the Angeles Forest Servi Mr. Jack Kearns, reported on the develo ment of facilities now available for t greater enjoyment of California's outdo play areas.

MERRILL BERKELEY, *Chairman Publicity Committe*

GSM&C

The Georgia Society for Measurement an Control held its Annual Dinner meeting i the Ellen Rice Tea Room on June 28, 194 The meeting was presided over by Retiri President M. C. Walker.

Sixteen members and their wives or date attended. To say a good time was had by a is an inadequate observation. Social Chai man M. V. Davis did an excellent job for th second consecutive year.

The new officers for the coming year ar *President*, Ralph Fishburn (Brown Instru ment Co.); *Vice-President*, M. Virgil Da (Atlantic Steel Co.); *Secretary*, Emory W Clark (Atlantic Industrial Laboratories) *Treasurer*, Roger Allen (Powers Regulat Co.).

Incoming President Fishburn gave a ver interesting talk on the history and progre of the Society from September 28, 194 High-light of the program was the Alum inum Company of America's technicolor fil "Unfinished Rainbows."

—E. W. CLARK, *Secretary*

JOURNAL of the Instrument Society of America

Editor, H. L. HILDENBRAND, Box 35, Onarga, Illinois
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Editorial

"PHILADELPHIA IN '48"

It is my hope that I can see every Secretary, Director and Journal Correspondent at Philadelphia in September. If I don't find you first, please look me up. It is helpful when we are dealing with those we know, and possibly things will go even more smoothly in the coming year if we can have a talk together.

H. L. HILDENBRAND

Official News

MEMBERSHIP AND SECTIONS COMMITTEE TO MEET SEPT. 16, 1948

This important committee will meet on Thursday, Sept. 16th, at 4:00 P.M. in Room 305, Convention Hall. Tentative agenda includes:

1—Study and recommend to the Executive Committee the benefits to be received by all classes of membership.
2—Foreign membership.
3—Simplify procedure for transferral between sections.
4—Assistance to local sections in arranging programs.
5—Steps to be taken when local sections are in difficulties.
6—Forming of sub-sections, particularly student sub-sections.

FINANCIAL REPORT

Treasurer H. E. Ferguson has prepared a financial statement covering the period from Jan. 1 to June 17, 1948.

Income from Membership (such as charter fees, dues, pin sales, etc.)	$15,181.77
Income from Meetings (sales of technical papers, proceedings, etc.)	77.21
Income from Exhibit (payment for space in Philadelphia show, etc.)	*42,649.00
Income from Headquarters quarters Activity	0.00
Income from Society Activities (such as I.S.A. Journal, book sales, etc.)	560.66
Total Receipts, 1/1 to 6/17	**$58,468.64**
Disbursements for Membership (such as billing, records, refunds to locals, magazine subscriptions, R. P. Binders)	$15,277.50
Expenses for Meetings (printing and distribution of notices, rentals, recording, reporting)	581.26
Expenses for Exhibit (promotional material, contracts, refunds, etc.)	1,521.61
Expenses of Headquarters maintenance (salaries, postage, office supplies, taxes, telephone, etc.)	4,991.19
Disbursements for Society Activity (such as printing, postage, expenses of secretary and president, legal fees, etc.)	4,214.95
Total Disbursements 1/1 to 6/17	**$26,586.91**
Cash in Live Stock National Bank, Chicago	$53,360.68
Cash in Bank of Nova Scotia, Toronto	1,163.00
Total Cash on Hand	**$54,523.68**
Vouchers Issued but uncashed	5,488.67
Unvouched bills in hands of Treasurer	0.00
Net Cash on Hand	**$49,035.01**

It should be noted that "Total Receipts" and "Net Cash" include prepayments for exhibit space in Philadelphia, but "Total Disbursements" does not include the expenses for the Third Exhibit. Hence, the cash position is not as good as this statement seems to show. It is probable that expenses for the Philadelphia exhibit will run about $29,000, leaving a profit of around $18,000. Since Disbursements for Membership (first item in the expense column) equals the income from the members, the show profit must cover all other activities of the Society for another year. Also, it should be noted that this statement shows practically all of the cash income the Society will have for 1948.

AN ADDITION TO THE BINDER

Another paper for inclusion in the Handbook binder has been released and probably every member has received a copy by this time. This addition contains abstracts of several papers on Automatic Regulators and Servomechanisms.

Report on Technical Committees

H. Frost, Chairman of the Committee on Technical Committee Structure, offers a new plan, which contemplates the establishment of channels whereby any papers submitted will have definite consideration for presentation and/or publication before the Society. If the plan is accepted by the Board of Directors in September, the Society will welcome offers of papers for presentation at future meetings.

Outline of Technical Division for I.S.A.

All technical activities in the Society shall be promoted through the Technical Division. The Technical Division shall be under the administrative supervision of one of the four elected Vice Presidents, selected by the President with the approval of the Executive Committee.

The Technical Division shall be comprised of a number of technical committees each representing a general field of interest in instrumentation. Each committee shall be headed by a chairman who shall be responsible to the Vice President in charge of the Technical Division. When required, subcommittees may be formed within a technical committee at the request of the chairman and with the approval of the Vice President in charge of the Technical Division. Chairmen of subcommittees shall be responsible directly to the chairman of the technical committee of which they are a part.

Technical committee chairman shall be members of the Society and shall be appointed each year by the Vice President in charge of the Technical Division with the approval of the Executive Committee. Membership of the committees and subcommittee chairman shall be appointed by the committee chairmen with the approval of the Vice President in charge of the Technical Division.

The technical committees shall promote activities in their respective interest fields, leading to the

1. Preparation of approved manuscripts of papers for presentation before regional and national meetings and for publication by the Society.
2. Preparation of recommended practices for adoption by the Society.
3. Preparation of recommended training programs for mechanics or others engaged in installing and maintaining instruments.
4. Preparation of educational programs for the benefit of the members of the Society and others interested in instrumentation.
5. Conduct of investigative work required to carry out any of the above objectives.
6. Conduct of research work on problems of a fundamental nature of general interest to members of the Society.
7. Preparation of technical reports covering investigative or research work.

All technical papers originating either from technical committee activity or presented to the Society for consideration for presentation or publication shall be directed to the Vice President in charge of the Technical Division or to an assistant whom he may appoint with the approval of the Executive Committee. Each paper must be reviewed and be recommended for presentation and/or publication by the proper technical committee before it can be considered. The Vice President in charge of the Technical Division, or his designated assistant, acting together with the technical committee chairmen, shall determine which papers are to be presented at a National or Regional meeting upon request from the Meetings Committee for papers for a scheduled meeting.

The following technical committees shall be included in the Technical Division. Three of these committees are presently standing committees in the Society.

Technical Committee on Instrumentation for Production Processes. The application of instrumentation to production processes of any kind falls within the field of interest